UNITED STATES
DEPARTMENT OF COMMERCE

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

MARITIME ADMINISTRATION
TITLE XI
TANK VESSELS ENGAGED IN
DOMESTIC TRADE

PENNSYLVANIA STATE UNIVERSITY
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Maritime Administration Title XI Tank Vessels Engaged in Domestic Trade

(X) Draft ( ) Final Environmental Statement

Responsible Office: U.S. Department of Commerce
Maritime Administration
Washington, D.C.

1. Type of Action: (X) Administrative ( ) Legal

2. Project Description:

To provide assistance in the construction of tank vessels in the guarantee of financial obligations (notes, bonds, etc.) including interest, that are obtained in the private market by U.S. citizens for the construction of such vessels in United States shipyards under Title XI financing.

3. Environmental Impacts:

Environmental impact of the program poses some degree of pollution risk to the marine environment and adjacent shoreline. The risk potential is related to adverse effects on the environment and other resource use which may result from cargo spillage of bulk liquids as a result of accidental collision or grounding and the release of contaminated water from operational procedures.

4. Alternatives Considered:

Alternatives to Title XI financing for the construction of tank vessels for the domestic trade have been considered in the statement and include withdrawing government support in providing guaranteed obligations to alternative modes of moving certain bulk liquids, such as by pipeline, railroad, motor carriers or aircraft.

5. Comments Requested:

Environmental Protection Agency
Department of State
Department of Defense
Department of Transportation
U.S. Coast Guard
Department of Treasury
Department of Energy
Department of the Interior
Bureau of Sport Fisheries and Wildlife
Bureau of Outdoor Recreation
Bureau of Mines
Geological Survey
Office of Oil and Gas

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State of Nebraska
State of New York
State of Ohio
State of Oklahoma
State of Oregon
State of Rhode Island
State of South Carolina
State of Tennessee
State of Texas
State of Virginia
State of Washington
State of West Virginia
State of Wisconsin

6. Draft Statement made available to the Environmental Protection Agency and the public

7. Final Statement made available to the Environmental Protection Agency and the public

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CHAPTER I

INTRODUCTION

Title XI Program Implementation of the Merchant Marine Act of 1970 for Tank Vessels Involved in Domestic Trade

This document is a programmatic Draft Environmental Impact Statement for the continued and future financing of tank vessels used solely in domestic trade under Title XI of the Merchant Marine Act of 1936 as amended in 1970. Other components of this Act which discuss Title XI funding for different vessel types, trade routes, and offshore drilling facilities are not covered in this report.

The Merchant Marine Act of 1970, which amended the 1936 Merchant Marine Act, made a number of changes designed to make the Maritime Administration Merchant Marine Program more attractive to private operators. For the first time under the 1970 Act the Title XI financing and loan guarantee program was extended to tank vessels.

CHAPTER II

DESCRIPTION OF PROGRAM

A. THE TITLE XI PROGRAM

1. INTRODUCTION AND PURPOSE

The primary purpose of the Title XI Program is to promote the growth and modernization of the United States Merchant Marine by issuing guarantees of obligations to enable the financing and refinancing of vessels constructed in the United States and owned and operated by citizens of the United States. The Program enables owners of eligible vessels to obtain long-term financing in the private capital market at favorable terms, conditions, and interest rates as available to the larger financially stronger corporations. Such favorable financing terms are usually not available to the average shipowner.

The Maritime Administration's financing has allowed several smaller U.S. companies to participate in the current expansion of tank vessel commerce in domestic waterways. This should provide healthier competition within the domestic waterborne commerce industry and hopefully reduce the transportation costs to the general public.

The Federal Ship Financing Program (hereinafter called the "Program") was established pursuant to Title XI of the Merchant Marine Act, 1936. This Act, as amended, provides for a full faith and credit guarantee by the United States Government for the purpose of financing or refinancing United States flag vessels constructed or reconstructed in U.S. shipyards. The Program is administered by the Assistant Secretary for Maritime Affairs on behalf of the Secretary of Commerce. The guarantee of the United States Government under this Program provides for the prompt payment in full of the interest on and the unpaid principal of any guaranteed obligation in the event of default by the shipowner in the payment of any principal and interest on the obligations when due or for other specified defaults.

The Program is used by the Secretary as a revolving fund for the purpose of underwriting the Government's guarantee and to pay the expenses of the Program. In addition, the Secretary is authorized to borrow from the United States Treasury in the event the Fund is insufficient for the purpose of making prompt payments under its guarantee. In November 1975 the President signed into law a bill providing for an increase in the statutory ceiling for Title XI to $7 billion.

2. ELIGIBILITY REQUIREMENTS

Vessels eligible for Title XI assistance under this phase of the Program include vessels designed principally for the shipment of bulk liquids and liquefied gases. However, any towboat, bulk liquid gas barge, canal boat, or tank vessel, to be eligible, must be more than 25 tons.

The design of the vessel must be adequate from an engineering viewpoint for its intended use, and the delivered vessel must be classed by the American Bureau of Shipping as Class A-1, or meet other standards acceptable to the Secretary. The shipowner must be a United States citizen and have sufficient operating experience and the ability to operate the vessel on an economically sound basis. The shipowner must meet certain financial requirements with respect to working capital and net worth, both of which are based on such factors as the amount of the guaranteed obligations, the shipowner's financial strength, intended employment of the vessel, etc. These factors also affect the terms of the guarantee with respect to continuing Title XI financial covenants, guarantee fees, reserve fund, etc. No guarantee under this program can be legally entered into unless the project is determined by the Secretary to be economically sound.

3. FUNDING PROCEDURES

Application forms for Title XI are obtained from the Maritime Administration. Approval of the application is contingent upon the determination of the Secretary as to whether the vessel(s) and the project meet all the applicable requirements of the existing statutes and regulations. If the application is approved, a conditional letter of commitment to guarantee the obligation is issued, stating the requirements necessary for

final approval. The applicant is notified in writing when the application is not approved. Final approval of the application is accomplished after the formal documentation of the transaction and all the conditions in the letter commitment are satisfied; at such time the Secretary enters into a formal Commitment to Guarantee, and guaranteed obligations (notes or bonds) are issued and sold and a secured interest or a mortgage on the vessel(s) recorded.

4. AMOUNT GUARANTEED

The amount of the obligation guaranteed by the government is based on the "actual cost" of the vessel as determined by the Secretary. The actual cost of a vessel includes those items which would normally be capitalized as vessel costs under usual accounting practices, such as the cost of construction, reconstruction, or reconditioning (including designing, inspecting, outfitting and equipping) of the vessel, together with commitment fees and interest on the related loan during the period of construction. All items of actual cost must be determined to be fair and reasonable by the Secretary. Some costs are excluded from actual cost (and are sometimes considered capitalizable costs) such as legal and accounting fees, printing costs, guarantee fees, vessel insurance and underwriting fees and any interest or borrowings for the shipowner's equity in the vessel(s). In addition, costs of foreign components are excluded from the actual cost (See Section A.8 for further detail).

The Secretary is authorized to guarantee an obligation which does not exceed 75 percent of the actual cost of most eligible vessels. However, obligations may be guaranteed in an amount not exceeding 87-1/2 percent of the actual cost of (1) passenger vessels, designed to be of not less than 1,000 gross tons and capable of a sustained speed of not less than 8 knots, to be used solely on inland rivers and waterways; (2) oceangoing tugs of more than 2,500 horsepower, (3) barges; (4) vessels of more than 2,500 horsepower designed to be capable of a sustained speed of not less than 40 knots (including hydrofoils); and (5) other vessels of not less than 3,500 gross tons and capable of a sustained speed of 14 knots. Vessels built with construction-differential subsidy or vessels other than barges and passenger vessels in (1) above engaged solely in the

transportation of property on inland rivers and canals exclusively are eligible only for a guarantee not exceeding 75 percent of their actual cost.

If a Title XI guarantee of an obligation for a vessel is documented after delivery or for refinancing, the actual cost must be depreciated from the date of delivery to the documentation date of guarantee.

5. SOURCE OF FUNDS

Since the Program is a guarantee program and not a direct loan program, funds secured by the guaranteed debt obligations and used for the financing of the vessel(s) are obtained in the private sector. The main sources for such funds include banks, pension trusts, life insurance companies and bonds sold to the general public.

6. AMORTIZATION AND INTEREST RATE

The maximum guarantee period is 25 years from the date of delivery; however, if the vessel has been reconstructed or reconditioned, the life may be extended by the Secretary to include the remaining useful years of the vessel as determined by the Secretary. Amortization in equal payments of principal is usually required; however, other amortization methods such as level debt (equal payments of principal and interest) may also be approved if sufficient security is offered such as long term charters, reduction of the amount of guarantee and/or length of guarantee period.

The interest rate of the obligation guaranteed, for both new and refinanced vessels, must be within the range of interest rates prevailing in the private market for similar loans and risks and must be determined to be fair and reasonable by the Secretary.

7. INVESTIGATION FEE

An investigation fee, not exceeding one-half of 1 percent of the original principal amount of the obligation to be guaranteed, is charged for the investigation of applications, including related appraisals and

inspections. Generally, a fee of only slightly in excess of one-eighth of the 1 percent is charged. If the application is not approved, one-half of the fee is refundable.

8. ANNUAL GUARANTEE FEES

The fee for the guarantee of an obligation for a delivered vessel will be not less than one-half of 1 percent or more than 1 percent per annum, of the average principal amount of the outstanding obligation, or not less than one-quarter of 1 percent or more than one-half of 1 percent per annum, of the principal amount of an obligation relating to a vessel under construction, reconstruction or reconditioning. Amounts of deposit for the vessel in an escrow fund held by the U.S. Treasury pursuant to Title XI are excluded in the computation of this charge. The fee is required by law to be paid annually in advance.

Unless otherwise determined by the Secretary, the annual premium rates are based on a ratio of net worth to long-term debt of the shipowner, and are subject to annual adjustment except during the construction period.

9. "BUY AMERICAN" POLICY

The Maritime Administration's long-standing policy has been that vessels built with the aid of Title XI are subject to the "Buy American" provision of Section 505 of the Merchant Marine Act which states in part: (1,2)

> "In all such construction the shipbuilder, subcontractors, materialmen or suppliers shall use, so far as practicable, only articles, materials, and supplies of the growth, production, or manufacture of the United States as defined in paragraph K of Section 401 of the Tariff Act of 1930."

Pursuant to Title XI the shipowner may be permitted to use components of foreign manufacture providing: (1) the performance of the vessel will not be adversely affected and (2) the incorporation of such foreign

components into the vessel will not impair its entitlement to operate in the coastwise trade of the United States or to carry preference cargoes. However, if foreign components are used, the cost thereof will be excluded from actual cost if the Secretary determines that suitable American domestically produced components are available. This reduction in the actual cost will increase the owner's share of the total cost of the vessel and reduce the amount of the guaranteed obligation.

10. REFINANCING

Amounts outstanding on existing Title XI obligations, or amounts outstanding on obligations not previously insured or guaranteed (provided they had been issued for the purposes contained in Title XI) may be refinanced under the Title XI program up to the amount of the existing obligations being refinanced. Such financing under Title XI must meet all the applicable requirements of the existing statutes and regulations, and the original obligation must have been issued within one year after vessel delivery. Vessels purchased as "used" vessels are not eligible under this provision. However, under certain conditions the proceeds of guaranteed obligations issued with respect to any eligible vessel may be used for the purchase of certain marine equipment.

11. CAPITAL CONSTRUCTION FUND

Vessels covered by the Jones Act are entitled to participate in the tax deferred capital construction fund. This fund was created by the Merchant Marine Act of 1970 to aid operators in accumulating the large quantities of capital necessary to build or convert ships. Under Section 607 of the Merchant Marine Act of 1970, any U.S. citizen owning or leasing an eligible vessel operated in the foreign/domestic commerce or fisheries of the United States may enter into an agreement with the Maritime Administration to obtain tax-deferred privileges on the earnings of these vessels and on the accumulated assets in the fund, provided these funds are used to acquire, construct or rebuild vessels to be operated in the United States, foreign, Great Lakes and non-contiguous domestic trades or in the fisheries.

B. DOMESTIC WATERBORNE SHIPPING (3,4,5)

1. INTRODUCTION

In the Merchant Marine Act of 1970, Congress re-emphasized the mandate to the Maritime Administration to promote a merchant marine sufficient to carry the nation's domestic waterborne commerce on all routes essential to maintaining the flow of such commerce at all times. The following discussion provides an overview of the major components of this domestic trade as they relate to the movement of bulk liquid commodities. It must be pointed out at this point, however, that while the following discussion deals with the entire domestic trade, only a very small portion of this trade actually receives Title XI Ship Financing Guarantees.

2. HISTORICAL PERSPECTIVE

The modern domestic waterborne trade was principally developed as a response to a national transportation policy to actively expand and promote domestic waterborne commerce. To foster this policy specific pieces of national legislation were enacted. The most significant of these acts are the Transportation Act of 1920, Merchant Marine Act of 1920 (The Jones Act) and the Merchant Marine Act of 1936.

The Transportation Act of 1920 declared it the policy of the Federal Government to promote, encourage and develop water transportation services and facilities... investigate the appropriate types and boats suitable for different classes of waterways, investigate water terminals and the interchange of traffic with the railroads.

The Merchant Marine Act of 1920, the Jones Act, provides for the protection of the U.S. merchant fleet by excluding foreign-built and foreign-operated ships from the U.S. domestic trades. The Jones Act (CABOTAGE LAWS) covers all waterborne transport between U.S. ports, including inland waterways, Great Lakes and the oceanborne trade between the United States mainland and the so-called non-contiguous area of Alaska, Hawaii and Puerto Rico.

Almost every maritime nation has similar legislation, even such highly competitive ones as Norway, Greece, Sweden and Japan. The principal purpose of the cabotage laws is to assure reliable service and to provide domestic maritime business, at least a minimum sized national fleet is maintained, a minimum market is preserved for the country's shipyards and various national and economic objectives are served. The shipyards are able to obtain some economies of trade and to maintain some merchant shipbuilding capability in times of crises. Under the Jones Act the Secretary of the Treasury has the authority to issue waivers to the Act in the interest of national defense.

3. CONTRIBUTION OF THE JONES ACT

Besides the success of the Jones Act in encouraging the development of a U.S. domestic fleet that can make major contributions to the nation's security, the Act has also been instrumental in stimulating U.S. ship construction, employment and financial benefits.

The domestic fleet has been a steady and prolific generator of new ship construction. From the very beginning, the domestic fleet was a prime market for U.S. shipbuilders who had declined with the end of WWI. The Merchant Marine Act of 1936 authorized the subsidization of the U.S. Marine fleet and led to shipbuilding incentives in the United States. It was not until after WWII with its surplus of war built vessels that the demand for domestic vessels had its greatest impact on shipbuilding.

After the war the domestic shipping industry was the prime shipbuilding customer until 1960 (see Table II-1). The national policies of the Jones Act and the Merchant Marine Act of 1970 have maintained a barely adequate U.S. shipbuilding capacity.

These policies provide approximately 15 percent of U.S. domestic commerce, generating considerable employment in the following professions:

12,000 shipyard workers engaged in building oceangoing vessels for the domestic trades.

Table II–1
POST WAR SHIPBUILDING DEMAND

YEAR	NUMBER		DOMESTIC SHIPBUILDING AS PERCENT OF TOTAL	DWT TONNAGE (000's)		DOMESTIC SHIPBUILDING AS PERCENT OF TOTAL
	DOMESTIC FLEET	FOREIGN FLEET		DOMESTIC FLEET	FOREIGN FLEET	
1950	4	0	100%	110	––	100%
1951	4	3	57%	85	34.5	71%
1952	4	7	36%	88	93	49%
1953	15	15	50%	355.7	202	64%
1954	15	10	60%	356	134.7	73%
1955	3	3	50%	57.6	42.9	57%
1956	5	0	100%	144	––	100%
1957	8	0	100%	269.5	––	100%
1958	15	4	79%	448	33	93%
1959	15	0	100%	512	––	100%
1960	9	9	50%	347	79	81%
1961	7	17	29%	300	203.7	60%
1962	3	25	12%	184.8	290	63%
1963	5	26	16%	195	318	36%
1964	4	11	27%	166	130.5	85%
1965	2	11	15%	92	144	68%
1966	1	12	8%	36	160.5	18%
1967	2	10	17%	18	131	12%
1968	4	17	19%	136	277	33%
1969	8	14	36%	230	104	69%
1970	7	3	30%	427	66	87%
1971	8	6	42%	471.5	169	74%
1972	6	7	53%	416	187.6	78%
1973	7	17	29%	400	437	48%
1974	5	11	32%	304	473	39%
1975	10	6	67%	340.8	486	41%
1976	8	13	38%	275	125.8	20%
1977	12	9	57%	950	854	53%
TOTAL	196	266	42% (Avg.)	7714.9	6176	56% (Avg.)
TOTAL CONST.	462 VESSELS			13,890.9 (000's) DWT		

- 24,000 employees in allied industries which support domestic ocean shipbuilding efforts.

- 20,000 employees of inland shipyards involved in building towboats and barges.

- 12,000 seamen aboard oceangoing vessels in the U.S. domestic ocean fleet.

- 93,000 workers on the nation's inland waters and lakes and nearby offshore vessels.

The Maritime Administration offers no direct subsidy (Title V - Construction Differential Subsidy or Title VI - Operating Differential Subsidy) to Jones Act operators.

Domestic waterborne commerce represents one of the major transportation modes for the movement of goods between intercities within the continental U.S. and the principal means of conveying goods to Hawaii, Alaska, Puerto Rico and the Virgin Islands. Of the five principal transportation modes; highway motor freight, railroads, airways, pipelines and water, waterborne accounts for approximately 24 percent of the total ton-mile volume of the domestic transport trade. Continuing developments in vessel design, vessel routings, and dockside industry indicate that the waterborne commerce may command a slightly larger percentage of the transport volume in the future.

The recent tonnage values of waterborne commerce illustrated in Table II-2 indicate that 979 million tons of domestic trade was generated in 1976 (4). As illustrated in Figure II-1, approximately 49 percent of the domestic trade was bulk liquid cargo as is being considered under this portion of the Title XI program. The volumes and statistics of the domestic waterborne trade are collected and compiled annually by the Department of Army, Corps of Engineers. The product classifications or groups considered under this action are the transport of crude petroleum, chemicals and allied products. The amount of Title XI financing contributed for bulk liquid carriers and their principal routes is indicated in Section C.

Table II–2
NET TOTAL WATERBORNE COMMERCE OF THE UNITED STATES, CALENDAR YEARS 1947– 1976
(in tons of 2,000 pounds)

YEAR	FOREIGN AND DOMESTIC TOTAL	FOREIGN TOTAL	DOMESTIC TOTAL
1947	766,816,730	188,256,115	578,560,615
1948	793,200,463	162,971,591	630,228,874
1949	740,720,971	165,358,281	575,362,690
1950	820,583,571	169,224,695	651,358,876
1951	924,128,411	232,055,832	692,072,579
1952	887,721,984	227,326,277	660,395,707
1953	923,547,693	217,396,489	706,151,204
1954	867,640,207	213,844,290	653,795,917
1955	1,016,135,785	271,102,932	745,032,853
1956	1,092,912,924	326,689,789	766,223,135
1957	1,131,401,434	358,539,550	772,861,884
1958	1,004,515,776	308,850,798	695,664,978
1959	1,052,402,102	325,669,939	726,732,163
1960	1,099,850,431	339,277,275	760,573,156
1961	1,062,155,182	329,329,818	732,825,364
1962	1,129,404,375	358,599,030	770,805,345
1963	1,173,766,964	385,658,999	788,107,965
1964	1,238,093,573	421,925,133	816,168,440
1965	1,272,896,243	443,726,809	829,169,434
1966	1,334,116,078	471,391,083	862,724,995
1967	1,336,606,078	465,972,238	870,633,840
1968	1,395,839,450	507,950,002	887,889,448
1969	1,448,711,541	521,312,362	927,399,179
1970	1,531,696,507	580,969,133	950,727,374
1971	1,512,583,690	565,985,584	946,593,106
1972	1,616,792,605	629,980,844	986,811,761
1973	1,761,552,010	767,393,903	994,158,107
1974	1,746,788,544	764,088,905	982,699,639
1975	1,695,034,368	748,707,407	946,326,959
1976	1,835,006,819	855,963,909	979,042,910

SOURCE: Waterborne Commerce of the United States, 1976.

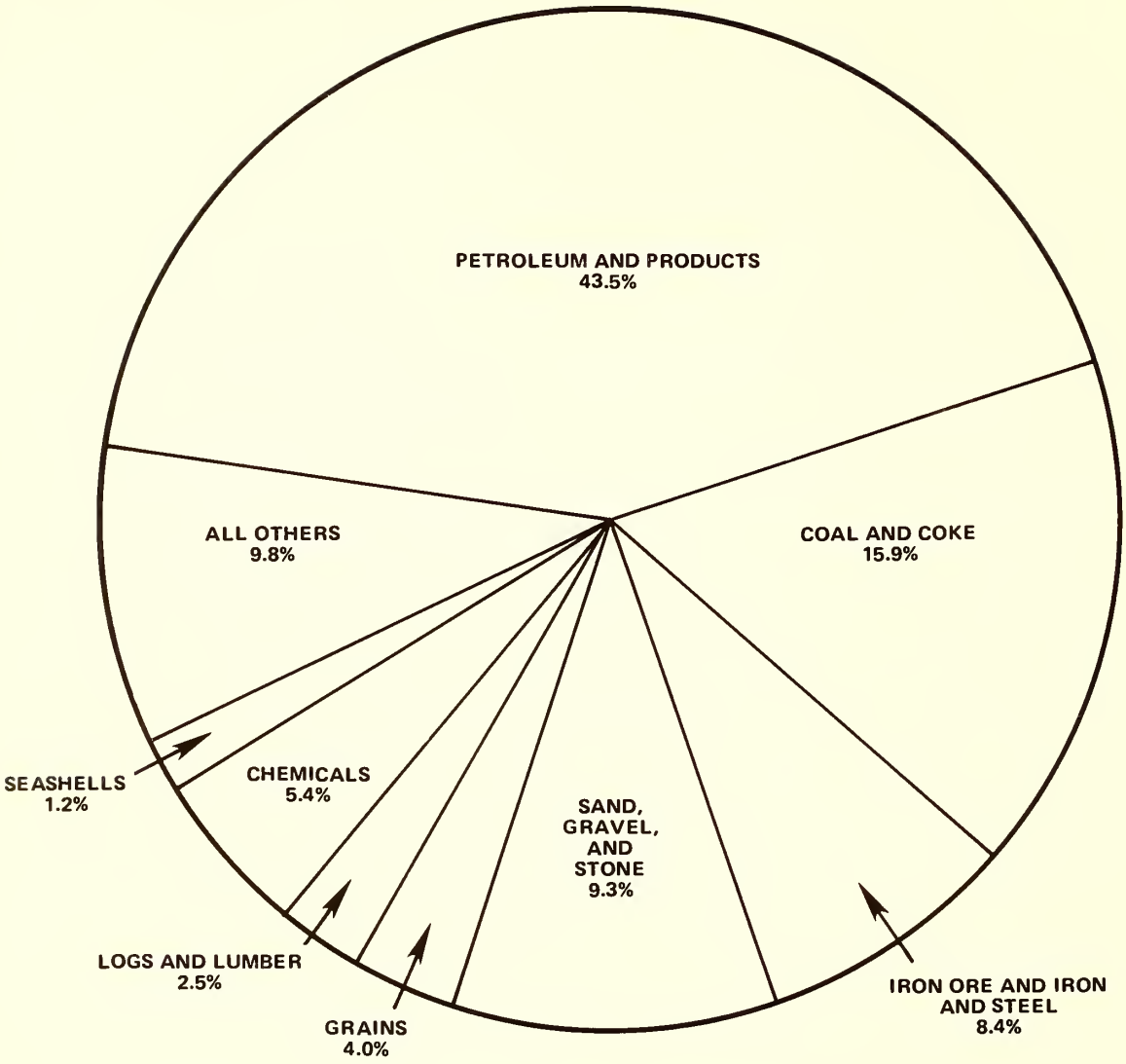


Figure II-1 DOMESTIC WATERBORNE COMMERCE (1976)

SOURCE: Waterborne Commerce of the United States, 1976

Domestic trade routes can be conveniently divided into: (1) the domestic ocean trade routes; (2) domestic inland waterways; and (3) the Great Lakes System. The amount of domestic trade in 1976 was approximately 233 million tons (24%) on the domestic oceans, 605 million tons (62%) on the inland waterways and 140 million tons (14%) on the Great Lakes (5).

4. DOMESTIC OCEAN TRADE

The domestic ocean trade may for convenience of analysis, be divided into four segments - contiguous trade (coastwise and intercoastal), Puerto Rican trade, Hawaiian trade, and Alaskan trade - comprising some 16 trade lanes. These lanes are illustrated in Figure II-2. Table II-3 shows the number and area of employment of vessels engaged in domestic ocean trade.

In 1976, approximately 76 percent of the domestic ocean trade was in the contiguous routes with the non-contiguous trade between the United States mainland and Puerto Rico, Alaska and Hawaii accounting for the remaining 24 percent. Of the 233 million tons of domestic ocean trade during 1976, gasoline, crude petroleum, distillate fuel, residual fuel and jet fuel accounted for 77 percent of the principal commodities carried. The remaining 23 percent is distributed among basic chemicals and other commodities.

These values will be changed with the advent of the crude oil transport of 200,000 tons per day from Valdez, Alaska to the Lower 48 States along Route 1 and possibly Route 10 illustrated in Figure II-2. In 1976, 207 million short tons of bulk liquid cargo were transported by tanker and tank barge in domestic ocean trade. Of the 207 million short tons of bulk liquid cargo, approximately 77 percent were transported by tanker and 23 percent by tank barge. On the average, tanker shipments of crude petroleum in domestic trade during 1976 amounted to 95,000 tons per day (5).

a. CONTIGUOUS TRADE

Tankers and tank barges in the contiguous trade carried 158 million short tons of bulk liquid cargo in 1976 (5). This is about 68 percent of the total cargo transported in the domestic ocean trade. Table II-4 shows

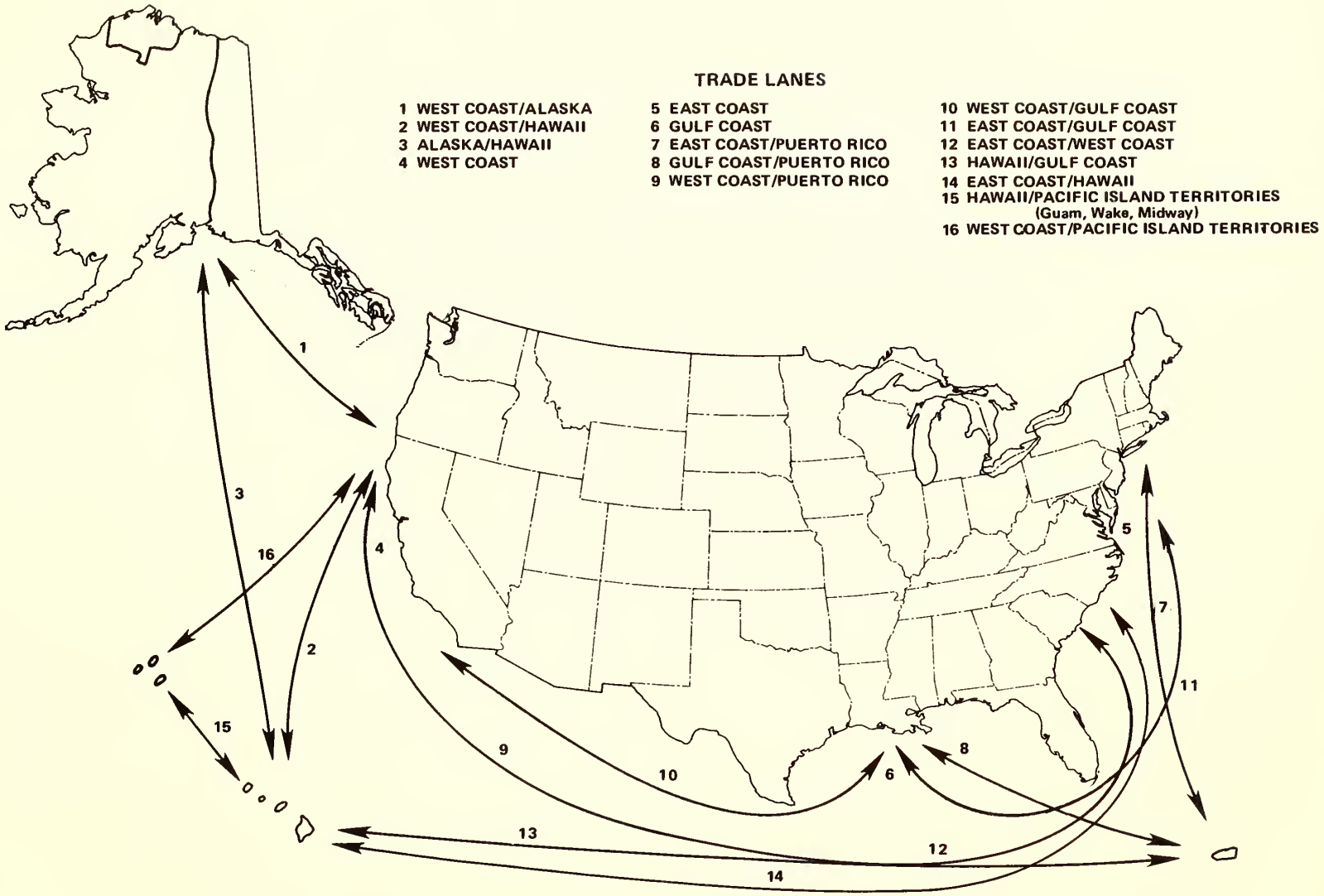


Figure II–2 DOMESTIC WATERBORNE TRADE LANES

SOURCE: Modified from Domestic Waterborne Shipping, Market Analysis, prepared by A.T. Kearney, Inc., Management Consultants, February, 1974.

Table II–3
SUMMARY OF AREA OF EMPLOYMENT IN DOMESTIC OCEAN TRADE *

AREA	NUMBER OF SHIPS
ATLANTIC COAST	45
GULF COAST	38
PACIFIC COAST	28
INTERCOASTAL	26
ALASKA	32
HAWAII	2
PUERTO RICO	7
TOTAL	178

* AS OF FEBRUARY 28, 1978.

SOURCE: Maritime Administration, February 1978.

Table II–4
TANK VESSEL FLEET IN THE CONTIGUOUS TRADE

VESSEL TYPE	NUMBER OF VESSELS	CARGO CARRYING CAPACITY (NET TONS)
SELF PROPELLED TANKERS*	150	4,571,000
TANK BARGES **	577	2,056,813
TOTAL	727	6,627,813

*MARAD, Feb 1, 1977
** Corps of Engineers, Jan. 1, 1976

the number and capacity of tank vessels employed in the contiguous trade.

The most significant restriction on modal capability for contiguous tanker traffic is the depth of harbors and channels at ports. The "average tanker size for the contiguous trade is 28,000 deadweight tons with sizes ranging from 10,000 to 60,000 tons. The "average" tank barge is approximately 3,500 deadweight tons; with sizes ranging from less than 1,000 tons to more than 10,000 tons. Based on cargo size alone, larger tankers are more economical even for the relatively short hauls in contiguous trade. Table II-5 shows the maximum permissible vessel size (when fully loaded) that can enter some of the selected U.S. coastal ports.

Table II-5 indicates existing U.S. ports are limited by controlling depths, which constrain the deadweight tonnage of tankers operating in domestic ocean trade. The table indicates most U.S. ports are limited to vessels under 50,000 DWT, with a very limited number of ports being able to accommodate tankers above 150,000 deadweight tons. The extreme northern and southern ports of the Pacific Coast are the only ones having enough depth to accommodate large vessels in the 150,000 to 250,000 DWT range.

Other physical factors that may dictate the future flow patterns of the contiguous trades are the development of deepwater ports and Alaskan oil reserves. The impact of Alaskan oil development is discussed later in this chapter. With regard to deepwater ports the number and location of these ports and the mode of transhipment may influence the number, size and type of vessels nedded to handle the movement of crude oil.

b. PUERTO RICAN TRADE

Several petroleum and chemical companies privately own or charter tank vessels in this trade. In 1976, approximately 40 million short tons of cargo were transported in the Puerto Rican trade (5). Strictly speaking, Virgin Islands trade is included in this value although this territory is not subject to the Jones Act. The principal bulk liquid commodities transported are residual fuel oil, naptha, distillate fuel oil, crude petroleum,

Table II-5
CONTROLLING DEPTH AND MAXIMUM PERMISSIBLE SIZE VESSELS FOR SOME CONTIGUOUS PORTS

PORT OR HARBOR AREA	CONTROLLING DEPTH (FEET)	ESTIMATED MAXIMUM PERMISSIBLE VESSEL SIZE WHEN FULLY LOADED (DWT)
EAST COAST		
DELAWARE RIVER PORTS	40	53,000
HAMPTON ROADS, VA	45	80,000
NEW YORK, NEW YORK	35	40,000
PORTLAND, ME	45	80,000
BALTIMORE, MD	42	53,000
BOSTON, MA	40	40,000
GULF COAST		
NEW ORLEANS, LA	40	50,000
TAMPA, FL	34	35,000
BATON ROUGE, LA	40	50,000
MOBILE, AL	40	45,000
CORPUS CHRISTI, TX	45	50,000
HOUSTON, TX	40	50,000
BROWNSVILLE, TX	36	30,000
PASCAGOULA, MI	38	35,000
PACIFIC COAST		
LONG BEACH, CA	52	150,000
LOS ANGELES, CA	51	150,000
SAN FRANCISCO BAY PORTS	35	40,000
PUGET SOUND, WA	73	250,000

SOURCE: US—124, Shipping Data, Waterborne: U.S. Department of Commerce, Maritime Administration Tanker Construction Program, Final EIS AN 73—0725—F, Washington, D.C.

gasoline, kerosene and chemicals. The total tonnage shipped and received in 1976 amounted to 32 million tons and 3 million tons, respectively.

c. HAWAIIAN TRADE

More than 9 million short tons of cargo were transported in the Hawaiian trade during 1976 (5). Tank barge traffic is minimal in the Hawaiian trade; however, bulk liquids shipped to and from Hawaii amounted to a little over 2 million tons in 1976. Bulk liquid commodities transported in Hawaiian trade are residual fuel oil, gasoline, distillate fuel oil, kerosene, molasses and naptha.

d. ALASKAN TRADE

In 1976, more than 13 million tons of cargo were transported in the Alaskan trade (5). The principal bulk liquid commodities transported were distillate fuel oil, jet fuel oil, gasoline, crude petroleum, residual fuel oil and chemicals. A little over 9-1/2 million tons were shipped and 3 million tons received. On the average, over 19,000 tons per day of crude petroleum was shipped from Alaska in 1976. The Alaskan pipeline which came on stream in 1977 created a substantial increase in crude oil transportation, as well as, an increase in tanker tonnage. The Trans-Alaskan pipeline began operation in the third quarter of 1977 at a flow rate of approximately 80,000 tons per day. During 1978, this throughput increased to about 160,000 tons per day and by 1980 with the addition of several more pumping stations, the line is expected to carry its full capacity of approximately 307,000 tons per day. It should be noted that known reserves place the optimum rate of oil at only 240,000 tons per day or 100 million barrels per day (assuming a specific gravity of 0.85 for oil). The tanker demand of West Coast ports for the Alaskan trade and the distribution of ship size as a function of pipeline flow rate is shown in Tables II-6 and II-7, respectively.

Title XI guaranteed tankers actually operating or planned for operation in Alaskan trade are listed with the vessel's major safety and environmental protection features in Table II-8. The size of the tankers for Alaskan trade is in the 37,000 to 265,000 DWT range with an average

Table II–6
TANKER DEMAND FOR ALASKAN OIL TRADE
120,000 DWT SHIPS ONLY

PORT	1977 .815 MMB/D	1978 1.420 MMB/D	1980 2.241 MMB/D (NO SURPLUS)	1980 2.241 MMB/D (.5 MMB/D SURPLUS PIPELINE FROM LONG BEACH)
PUGET SOUND	1.49	2.59	4.10	3.18
SAN FRANCISCO	4.92	8.57	13.52	10.50
LONG BEACH	6.37	11.08	17.50	22.27
TOTAL NUMBER OF VESSELS	12.78	22.24	35.12	35.95
TOTAL DWT (THOUSAND)	1,534	2,669	4,214	4,314

SOURCE: Maritime Administration, 1977.

Table II–7
FORECAST OF TOTAL NUMBER OF SHIPS BY SIZE IN VALDEZ–
WEST COAST SERVICE

PHASE	PIPELINE FLOW RATE (M BPD)	SHIP SIZE (M DWT)								
		150	130	120	90	80	75	70	60	45
I	600	1	1	2	0	3	1	1	3	1
II	1,200	1	3	7	2	3	1	1	3	1
III	2,000	1	5	16	2	2	3	2	3	1

SOURCE: Criteria and Design Bases Appendices, Alyeska Pipeline Service Co., Houston, Texas.

Table II–8
SAFETY AND ENVIRONMENTAL PROTECTION FEATURES ON TITLE XI TANKERS OPERATING IN THE ALASKAN OIL TRADE AS OF MAY 1978

VESSEL NAME	DWT (000)	YEAR BUILT	IMCO SEGREGATED BALLAST	DEFENSIVE SPACES	DOUBLE HULL OR BOTTOM	INERT GAS	LORAN C	COLLISION AVOIDANCE SYSTEM
AQUILA	80	1973	–	–	–	–	X	–
ATIGUN PASS[1]	165	1977	X	–	–	X	X	X
CHESTNUT HILL	90	1976	X	X	DOUBLE BOTTOM	–	X	X
KEYSTONE CANYON	165	1978	X	–	–	X	X	X
MANHATTAN	114	1962	–	–	–	–	–	X
MARYLAND	265	1976	X	–	–	–	X	X
NEW YORK	265	1976	X	–	–	–	X	X
OVERSEAS ARCTIC	62	1971	–	–	–	–	–	X
OVERSEAS VALDEZ	37	1968	–	–	–	–	–	X
OVERSEAS CHICAGO	90	1977	X	X	DOUBLE BOTTOM	–	X	X
OVERSEAS NEW YORK	90	1977	X	X	DOUBLE BOTTOM	–	X	X
SOHIO INTREPID	80	1971	–	–	–	–	X	–
SOHIO RESOLUTE	80	1971	–	–	–	–	X	–
STUYVESANT	225	1977	X	–	–	–	X	X
THOMPSON PASS[2]	120	1978	X	X	DOUBLE HULL	X	X	X
BROOKS RANGE	120	1978	X	X	DOUBLE HULL	X	X	X

NOTES: 1 In addition, there are 2 other Atigun Pass class vessels (165,000 DWT) projected to enter the trade in 1978.

2 To enter service in late 1978.

X = Vessel has feature indicated

SOURCE: Maritime Administration, May 1978.

tanker size being 128,000 DWT. Of the 16 tankers listed in Table II-8, 13 tankers have collision avoidance systems and LORAN C, 10 tankers have IMCO segregated ballast, 5 tankers have defensive spaces, 4 tankers have inert gas systems, 3 tankers have double bottoms and 2 tankers have a double hull design.

e. TYPICAL VESSELS OF THE DOMESTIC OCEAN TRADE

Typical vessels employed in domestic ocean trade for the shipment of bulk liquid cargoes consist of self-propelled tankers and oceangoing barges using the conventional or integrated tow system.

The self-propelled tanker is generally larger, faster, and more expensive than a comparable barge system. For economical operation of these vessels the tanker port time has to be minimized and the number of ton-mile revenues maximized. More than 80 percent of the bulk liquid commodities, petroleum in particular, are transported in self-propelled tankers. Figure II-3 illustrates one of the large new self-propelled tankers of the 70,000 DWT capacity designed to transport Alaskan crude oil.

There are only a few chemical tankers employed in the domestic trade. Most of the chemical cargo transported in domestic trade is by barge. The chemical tankers are designed to meet the U.S. Coast Guard Dangerous Cargo regulations and the Bulk Chemical Code developed by the Intergovernmental Maritime Consultative Organization (IMCO). The Code categorizes the chemicals by the degree of hazard they present to the environment and corresponding ship designs are specified to minimize damage and contain the cargo in the event there is a vessel casualty.

Currently there is no domestic trade in liquefied natural gas and only small domestic trade in liquefied propane and butane gases. The method of transportation to be used to bring the North Slope gas to the Lower 48 States was determined to be by pipeline across Canada to the central United States (6,7). However, new gas supplies from the National Petroleum Reserve number four in the north and potential gas fields in other parts of Alaska will present opportunities for the transport of LNG by domestic tankers. Studies are now in progress to investigate alternate

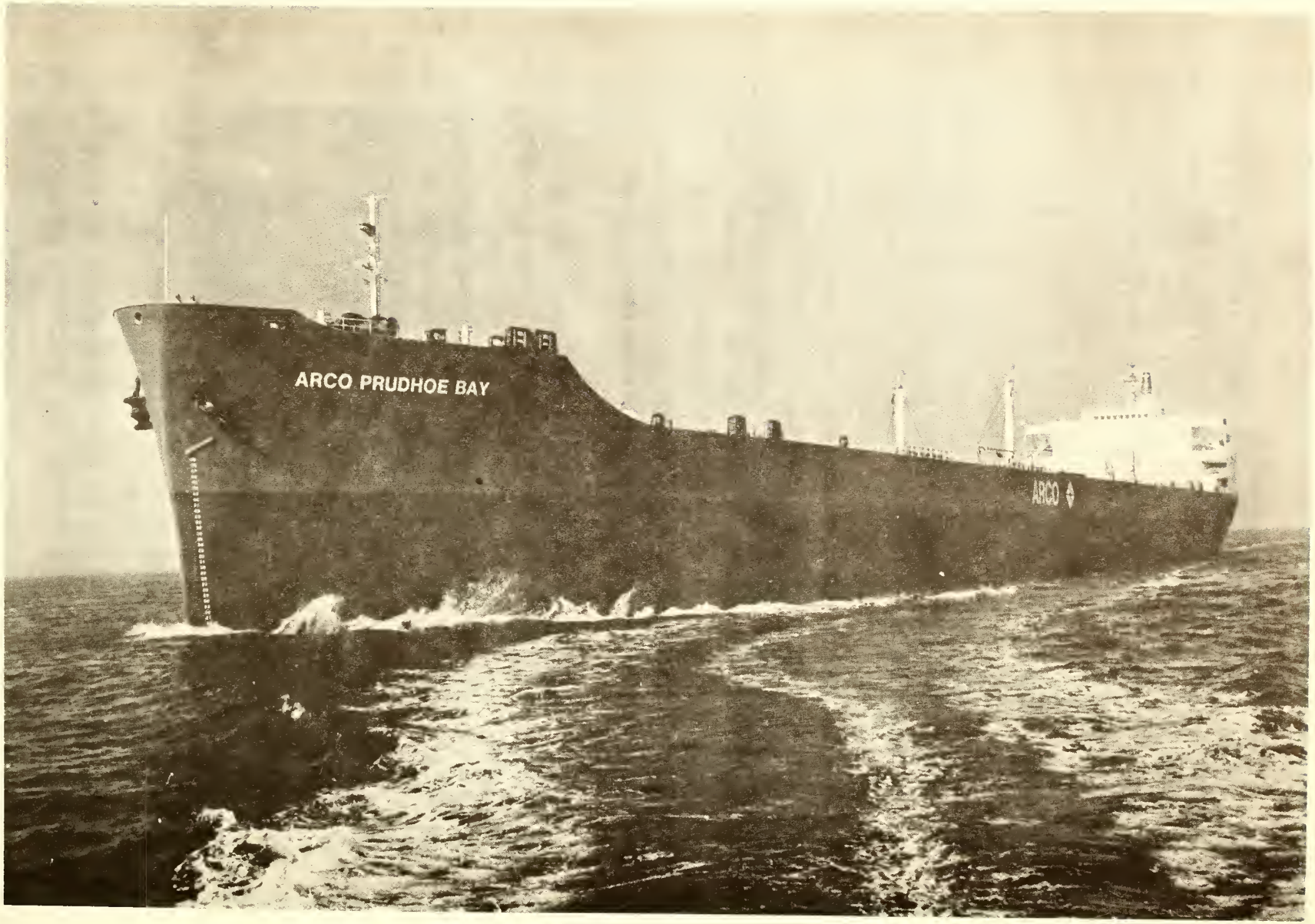


Figure II–3 THE ARCO PRUDHOE BAY – LARGE NEW AMERICAN MERCHANT TANKER OF 70,000 DWT CAPACITY

shipping routes of LNG from Alaska. It would be expected that the current LNG and LPG vessels which are engaged in foreign trade, or a similar vessel design, would be developed for this trade. Figure II-4 illustrates a cryogenic tanker designed to transport liquefied natural gas at a temperature of minus 260°F.

The integrated barge system is employed quite frequently in the domestic ocean trade. The operation of an integrated barge differs from that of a conventional barge system. The conventional barge is towed behind a tugboat with a hawser and the integrated system requires the tug and barge to be mechanically connected. The integrated system as illustrated in Figure II-5 permits a number of barges of differing sizes and geometries to be built. The only requirement being the tug and barge have a compatible hull design. With this design the integrated barge acts as a ship and is able to safely handle heavy seas. The conventional barge system must be towed by hawser in heavy seas, an inefficient and sometimes dangerous operation.

While integrated barges and tugs are not intended to be separated at sea, except in an emergency, each is seaworthy and certified for unrestricted ocean service. With this design, if the barge were to be threatened by sinking or fire, the tug could be saved by remote control upcoupling.

Although an integrated tug barge could be used for any service, its principal application has been for coastwise petroleum trade. The typical barge hull has a ship type bow, a sloping stern, and is subdivided into four separate cargo parcels containing three tanks each. Maneuvering is aided by a transverse lateral bow thruster. The barge is constructed for unrestricted ocean and coastwise service and is designed to compete with small tankers both being in the 35,000 to 37,000 deadweight range. It is generally a single skinned conventionally designed hull without segregated ballast capacity except the peak tanks.

Technically, vessel maneuverability is the only distinguishable difference between the tanker and integrated tug/barge with regard to potential environmental effects. All of the integrated tug/barge units

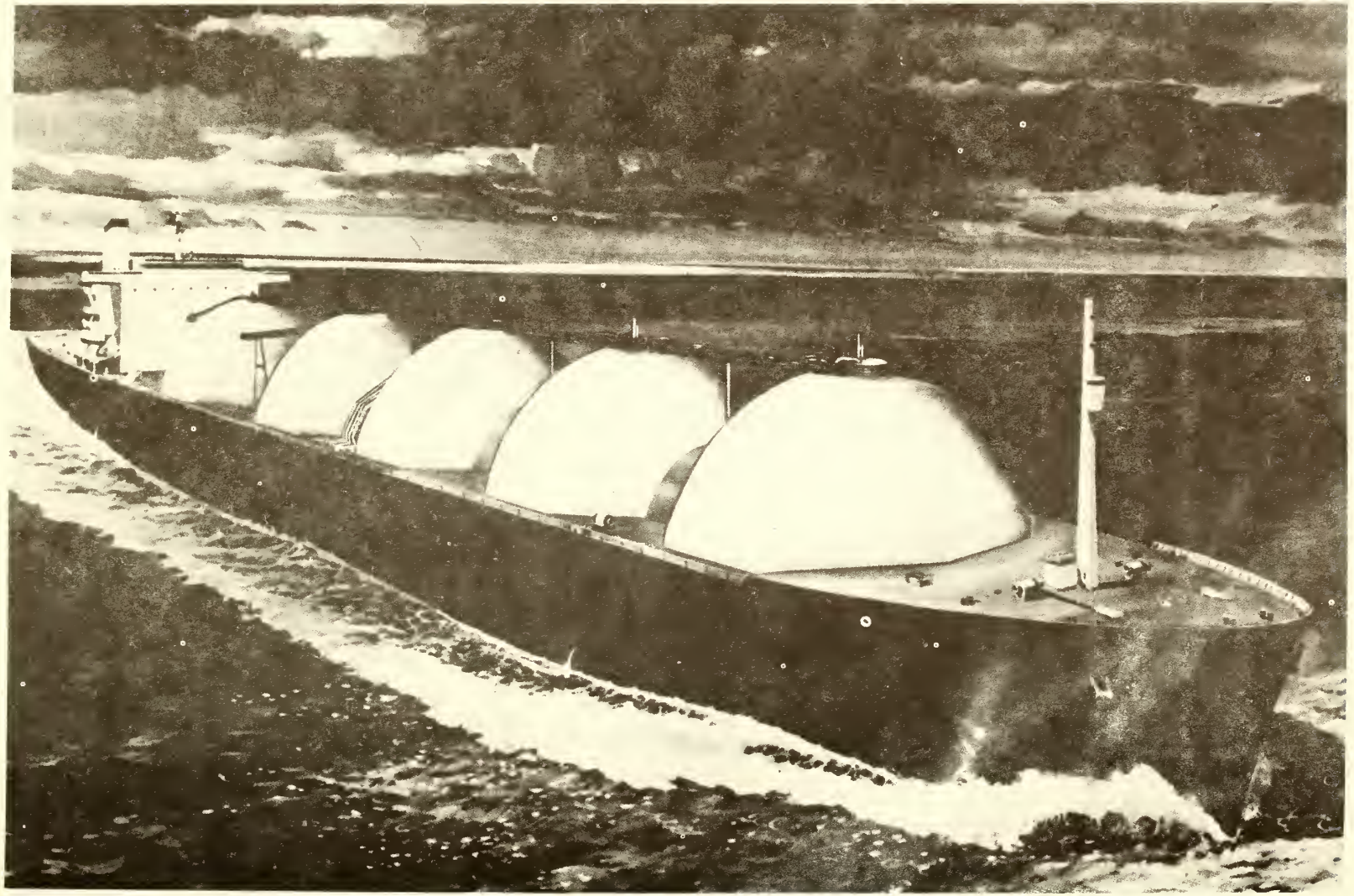
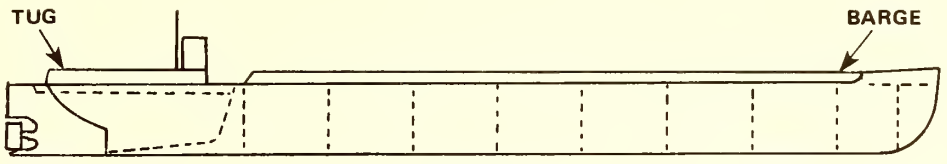
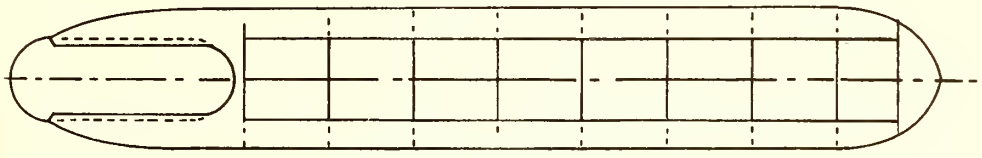


Figure II–4 TYPICAL CRYOGENIC TANKER



PROFILE



PLAN VIEW AT MAIN DECK

TYPICAL INTEGRATED TUG BARGES CHARACTERISTICS ARE AS FOLLOWS:

	TUG	BARGES	COMBINATION
LOA	156' – 6"	532' – 0"	620' – 6"
BEAM	46' – 0"	87' – 0"	
DEPTH	33' – 4"	46' – 4"	
DRAFT	29' – 3"	37' – 5"	
LIGHT SHIP	1,250 l.t.	5,800 l.t.	7,050 l.t.
DEADWEIGHT		36,500 l.t.	36,530 l.t.
FULL LOAD DISPLACEMENT			
TYPE OF PROPULSION	TWIN SCREW DIESEL		
SHP	11,000		
SPEED			14 KNOTS

Figure II–5 INTEGRATED TUG–BARGE SYSTEM

SOURCE: Maritime Administration, 1977.

in service or under construction are of twin-screw design, which offers better maneuverability per unit of horsepower than the single-screw design typical of tankers. Given similar features such as power, number of screws and thrusters, the maneuverability, stopping distance, controllability and other parameters are virtually unchanged from conventional ships of similar size. In such a case, there would be no significant environmental differences between these competitive systems.

5. INLAND WATERWAYS TRADE (3,4,5)

a. MAJOR WATERWAYS

The contiguous inland waterways system as illustrated in Figure II-6 is a network of over 28,000 miles of navigable waters. The major artery of this system is the Mississippi River system. Other major sections of the inland waterways are tabulated in Table II-9.

The Mississippi River and the Gulf Coast waterways (exclusive of the Gulf Intracoastal waterway from St. Mark's, Florida to the Mexican Border) represent 63 percent of the mileage of the contiguous navigable waterways. Since these routes are contiguous, the same vessels often move throughout the system. In effect, the Mississippi River system and the Gulf Coast waterway form one inland water route. Fifty percent of this 17,645 mile network has a channel depth of nine feet or more. A channel depth of nine feet is considered the minimum desired channel depth although waterways with less than nine feet depth are navigable.

Many of the waterways are made navigable by the installation of dams to form navigable pools. The dams are traversed by means of locks which raise or lower vessels to the level of the water on the opposite side of the dam. The inland waterway system contains approximately 150 locks.

The inland waterways industry operates approximately 2,979 tank barges with a total cargo carrying capacity of about 6,295,236 tons. The freight moving on the inland waterways is mostly carried in unmanned, non-self-propelled barges having drafts of six to twelve feet. In 1976, 605,292,000 tons of cargo were transported on the U.S. inland waterways system. Bulk

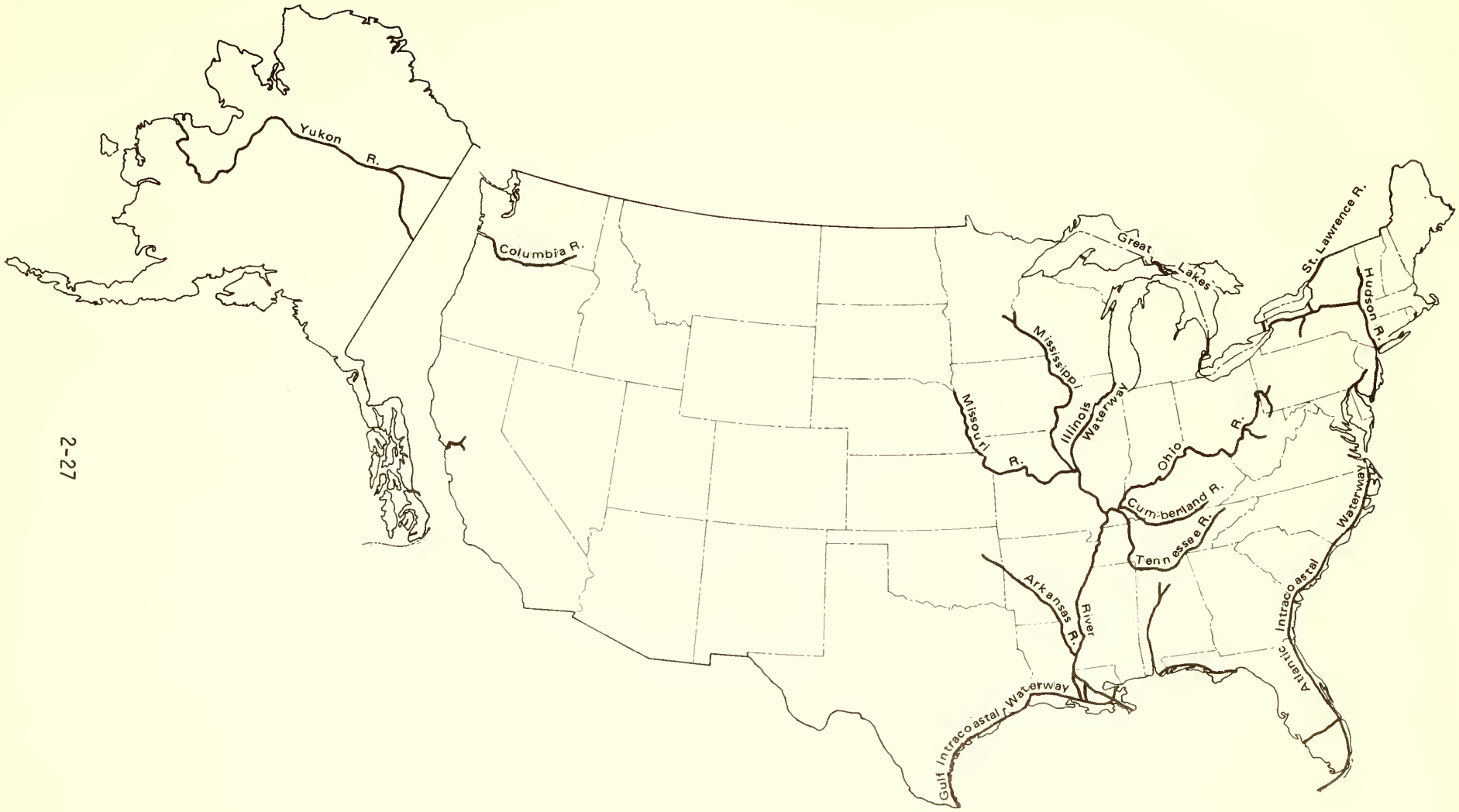


Figure II-6 MAJOR INLAND WATERWAYS

SOURCE: Adapted from: Ohio River Basin Comprehensive Survey, U.S. Army Corps of Engineers, Vol. XIII, Appendix L, April 1968

Table II–9
NAVIGABLE LENGTHS AND DEPTHS OF UNITED STATES WATERWAY ROUTES [1]

GROUP	LENGTH IN MILES OF WATERWAYS						
	UNDER 6 FT.	6 TO 9 FT.	9 TO 12 FT.	12 TO 14 FT.	14 FT. AND OVER	TOTAL	% OF TOTAL
ATLANTIC COAST WATERWAYS (exclusive of Atlantic Intracoastal Waterway from Norfolk, Va., to Key West Fla. but including New York State Barge Canal System)	1,426 1,487	1,241 1,445	584 589	938 965	1,581 1,544	5,770 6,030	23.6 21.5
ATLANTIC INTRACOASTAL WATERWAY FROM NORFOLK, VA.. TO KEY WEST, FLA.	– –	65 160	65 65	1,104 1,104	– –	1,234 1,329	5.0 4.7
GULF COAST WATERWAYS (exclusive of Gulf Intracoastal Waterway from St. Marks River, Fla., to Mexican Border)	2,055 2,174	647 812	1,133 2,095	79 269	378 388	4,292 5,378	17.6 20.5
MISSISSIPPI RIVER SYSTEM	2,020 4,365	969 1,457	4,957 5,062	740 755	268 268	8,954 11,907	36.7 42.5
PACIFIC COAST WATERWAYS	730 733	498 515	237 237	26 27	2,084 792	3,575 2,304	14.6 8.3
GREAT LAKES	45 100	89 138	– 14	8 8	348 369	490 629	2.1 2.2
ALL OTHER WATERWAYS (exclusive of Alaska)	76 76	7 7	– –	1 1	7 7	91 91	0.4 0.3
GRAND TOTAL	6,352 8,935	3,516 4,534	6,976 8,062	2,896 3,129	4,666 3,368	24,406 28,028	100.0 100.0

1 The mileages shown in this table in the first line of each group represent the lengths of all navigable channels of the United States including those improved by the Federal Government, other agencies, and those which have not been improved but are usable for commercial navigation.

The mileages shown in this table in the second line represent the lengths authorized by the Congress of the United States in legislation known as Rivers and Harbors Acts.

The sources for these tabulations are publications of the Corps of Engineers, United States Army.

liquid transport constituted approximately 45 percent of the trade. The Mississippi River system in 1976 handled approximately 47 percent of the domestic waterborne commerce.

b. TYPICAL VESSELS OF THE INLAND WATERWAYS TRADE (8)

Within the inland waterways the predominant vessels utilized are non-self-propelled vessels (i.e., unmanned barges). Individual barges are joined together, as illustrated in Figure II-7 to form a tow which is essentially a hydrodynamically single large vessel. This system is used to reduce the water resistance and allow greater maneuverability. The barges within the respective waterway systems are sized for efficient load sizes within the confines of the channel depths, lock size, and channel dimensions.

Liquid cargo barges are generally designed for a specific service, such as hauling specialized chemicals. It is not uncommon that a tank barge is designed for a specific service and cannot be utilized for other cargoes.

Four basic types of tank barges are used for the transportation of liquid commodities. Three types are generally used to carry oil and chemicals and the fourth type is used in the movement of liquids under pressure.

Single skin tank barges have bow and stern compartments separated from the midship by transverse collision bulkheads. The entire midship shell of the vessel constitutes the cargo tank. Structural strength considerations require that this huge tank be divided by bulkheads. The hull structural framing is inside the cargo tank (9).

Double skin tank barges can be subdivided into two categories, double wall and double hull. The double wall vessel has an inner and outer double side shell and a single bottom shell while the double hull barge has both it s sides and bottom as a double shell. The inner shell forms cargo tanks free of appendages and they are thus easy to clean and

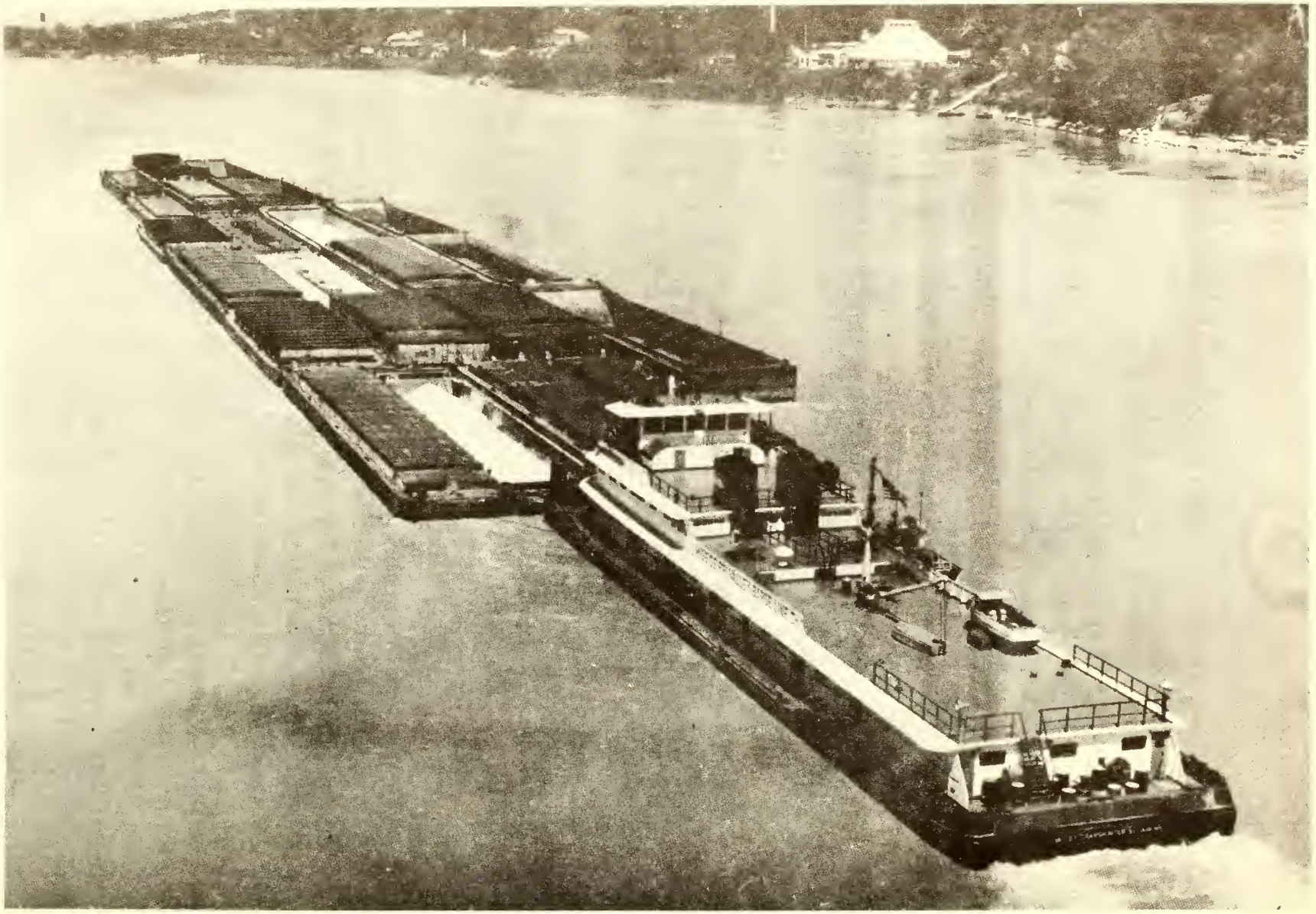


Figure II–7 INLAND WATERWAYS TUG–BARGE SYSTEM

SOURCE: Maritime Administration, 1977

to line. Poisonous and other hazardous liquids require the protection of the void compartments between the outer and inner shells. The size distribution of the single and double skin barge fleet is shown in Table II-10 (9).

Barges having independent cylindrical tanks are used to transport liquids under pressure or in cases where pressure is to be used to discharge the cargo. Cylindrical tank barge design as illustrated in Figure II-8 is used in some cases to carry cargoes at or near atmospheric pressures because of the high efficiency of linings and/or insulation which can be incorporated. Cylindrical cargo tanks are generally mounted in the barge hopper and are thus free to expand or contract independent of the hull structure. For this reason, too, they are preferred for high temperature cargoes such as liquid sulphur at 380 degrees Fahrenheit, or refrigerated cargoes such as liquefied natural gas at minus 258 degrees Fahrenheit. The LNG Barge Massachusetts illustrated in Figure II-9 is a typical cryogenic tank barge employed in domestic trade to transport liquefied natural gas from the Boston Gas Import Terminal, Dorchester, Massachusetts to gas terminals in Providence, Rhode Island and New York.

6. GREAT LAKES TRADE (THE SEAWAY SYSTEM) (3,6)

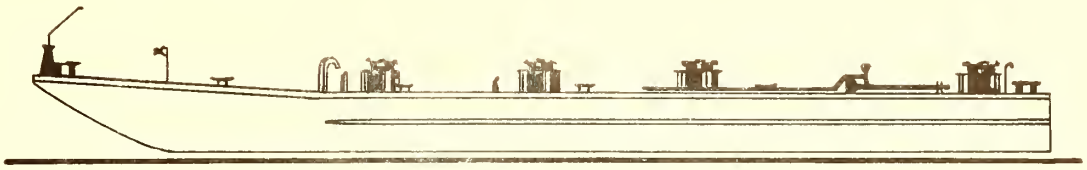
a. GENERAL

The Great Lakes Seaway System, as illustrated in Figure II-10, extends 2,342 miles from the Atlantic Ocean to mid-continent serving many of the key industrial centers of mid-America, including Cleveland, Detroit, and Chicago. The Seaway System connects with the inland waterway system at three points: with the New York State Barge Canal in Upper New York State at Buffalo; into Lake Erie and through the Oswego Canal into Lake Ontario; and with the Illinois Waterway at the tip of Lake Michigan in Chicago's Calumut Harbor. As can be seen in Figure II-10, the largest freight throughput occurs on Lakes Huron and Superior, however, the largest freight traffic tonnage per port occurs at Chicago and Duluth which are located at the extremities of Lake Michigan and Lake Superior, respectively.

Table II–10
TYPICAL SIZE DISTRIBUTION OF INLAND WATERWAYS TANK BARGE FLEET

MAJOR SIZE CATEGORY	SINGLE SKIN	DOUBLE WALL	DOUBLE HULL	TOTAL
50 x 20	163	2	36	201
110 x 40	311	8	61	380
195 x 35	431	18	432	881
155 x 45	281	4	59	344
240 x 50	486	35	107	628
290 x 54	230	38	43	311
TOTAL NUMBER	1,902	105	738	2,745

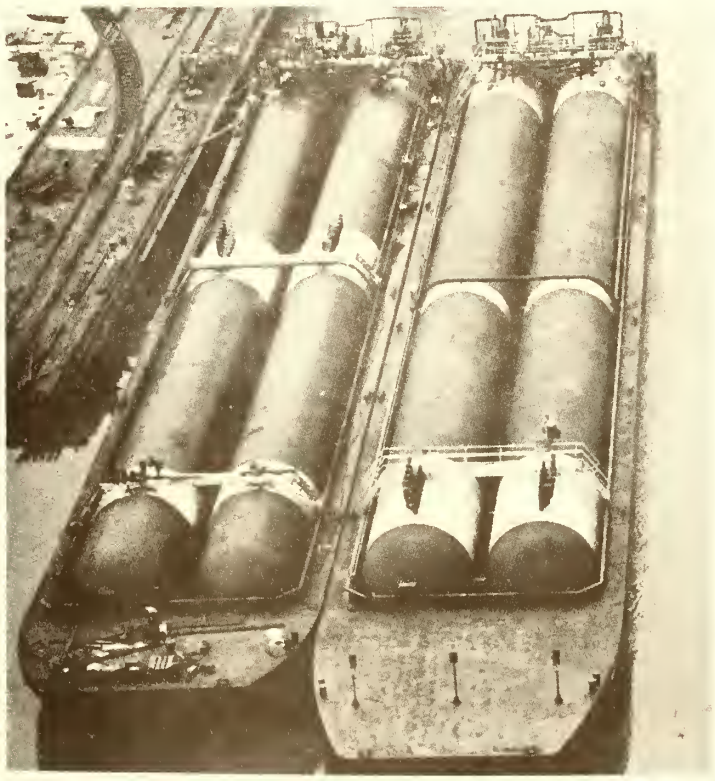
SOURCE: Joint MARAD/USCG Tank Barge Study, October 1974.



RANGE OF PRINCIPAL SIZES AND CAPACITIES

LENGTH FEET	BREADTH FEET	DRAFT FEET	CAPACITY TONS	CAPACITY GALLONS*
175	26	9	1,000	302,000
195	35	9	1,500	454,000
290	50	9	3,000	907,200

*Based on an average of 7.2 barrels per ton and 42 gallons per barrel.



(NOTE THE GIANT INDEPENDENT CYLINDRICAL TANKS)

Figure II–8 TYPICAL RIVER BARGES FOR TRANSPORT OF LIQUID CHEMICALS

SOURCE: Adapted from: Big Load Afloat, A Publication of the American Waterway Operators, Inc., Washington, D.C.

CONSTRUCTION DATA	OWNERSHIP	SHIP PERFORMANCE	DESIGN FEATURES	CAPACITY
SHIPYARD: TODD SHIPYARDS CORP. HOUSTON, TEXAS, USA DATE: 1973 DIMENSIONS: LENGTH – 297 feet BEAM – 60 feet DRAFT – 15.5 feet SUMMER DWT: 3,500 est.	OWNER: COASTAL CRYOGENICS/ MORAN TANK SHIP HO. (DISTRIGAS) ROUTE: EASTERN SEABOARD USA FLAG: USA	PROPULSION: 2 THRUSTERS BHP or SHP: 3,200 hp tug	NO. OF TANKS: 4 DESIGN: HORIZONTAL CYLINDRICAL ALUMINUM TANKS INSULATION: PERLITE	CUBIC METERS: 5,000 METRIC TONS: 2,155

LNG BARGE MASSACHUSETTS

Figure II–9 LNG BARGE MASSACHUSETTS

SOURCE: Ocean Industry, November, 1974.

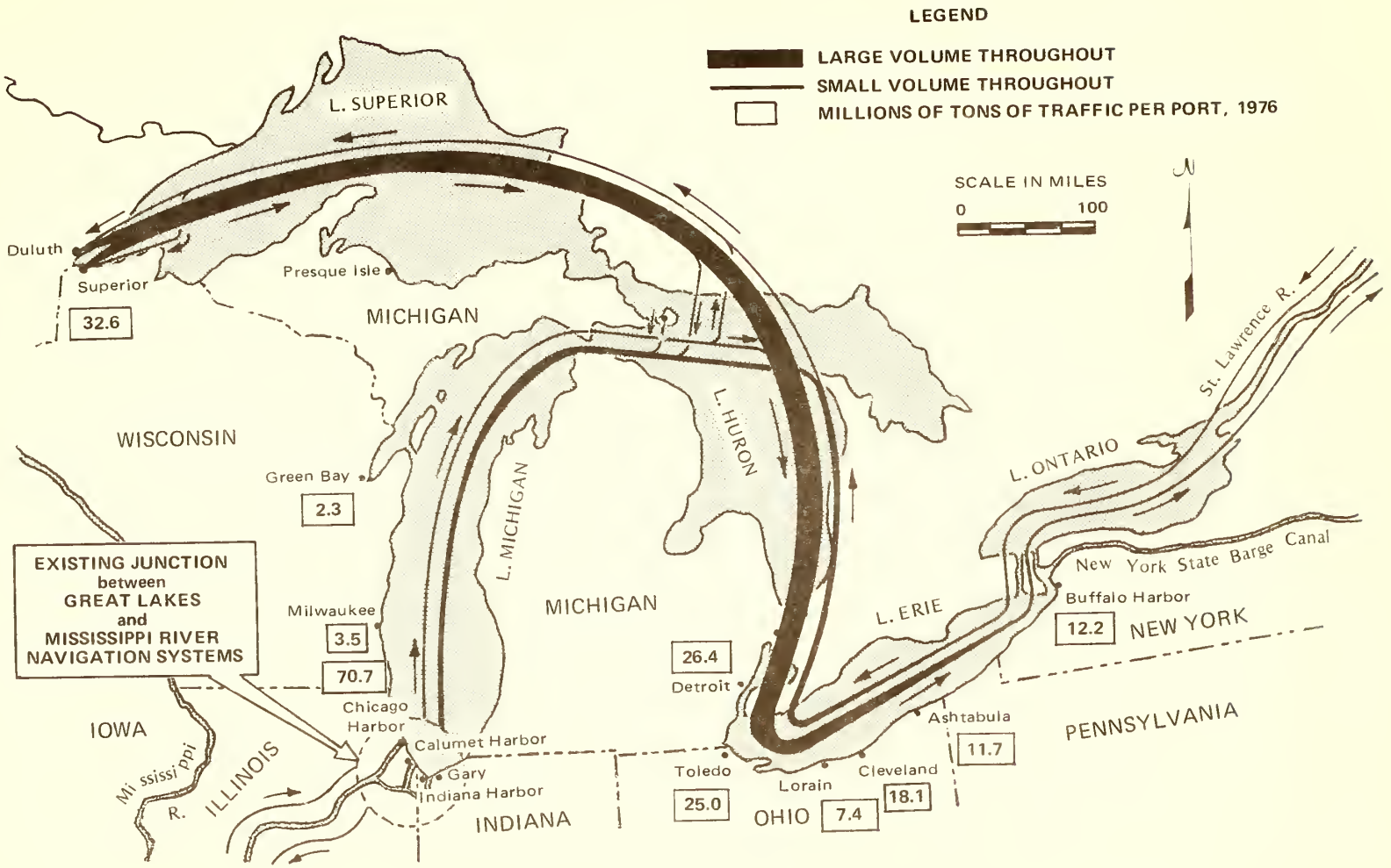


Figure II– 10 GREAT LAKES NAVIGATION SYSTEM DOMESTIC FREIGHT TRANSPORT

SOURCE: Illustration adapted from Ohio River Basin Comprehensive Survey, Vol. XIII, Appendix L, Navigation, Army Corps of Engineers, Cincinatti, Ohio, 1968.

Tons of Freight Traffic per Port from Waterborne Commerce of the United States, Department of the Army, Corps of Engineers, Part 5, 1976.

The Great Lakes Seaway System has a number of navigational limitations and restrictions on its use as a transportation artery. One of the major physical disadvantages of the Great Lakes System is that it requires a circuitous route between many of the major lakeside centers of economic activity. The added extra travel distances and the winter ice shutdown have tended to discourage increased waterway utilization. In addition, vessel navigation is hampered by high wave action and water level fluctuations causing draft problems in interconnecting canals.

The impact of water levels on available vessel draft is a significant factor in vessel transport costs. Available drafts on the Great Lakes are affected in two ways. First, there is a natural fluctuation on the level of the Great Lakes themselves which will impact on the water levels in connecting waterways. During the years 1962 to 1968, water levels varied as much as 3.55 feet in Lake Superior and 5.76 feet in Lakes Michigan and Huron. Second, the level to which interconnecting channels are dredged has a direct impact on available vessel draft. Due to the rougher water conditions encountered in the Great Lakes, the typical inland waterway barge is not suited to operation on the Great Lakes. Even lake-worthy barges cannot typically be operated in lengthy tows such as found on the Mississippi River because the wave action of the Lakes will break the two apart. Consequently, barging operations of the Great Lakes are limited to one or two barges being pushed or towed.

Since the major oil distribution to middle America is from the south, there are no primary markets for the domestic movement of crude petroleum and natural gas on the Great Lake System. Consequently, bulk liquid transport comprises only approximately 4 percent of the total 1976 cargo tonnage that is moved on the Great Lakes System. In 1976 only a little over 6 million short tons of bulk liquid cargo were transported on the Great Lakes.

b. TYPICAL VESSELS OF THE GREAT LAKES TRADE

The tankers and tank barges employed in the Great Lakes Trade are essentially the same as those operating in the domestic ocean trade and the inland waterways trade, respectively. Since the descriptions of these

vessels were presented earlier in Sections B.4.e. and B.5.b., they will not be repeated here.

The U.S. Great Lakes fleet consists primarily of dry cargo bulk carriers with tankers playing a decreasing role as more petroleum products are moved by pipeline. Table II-11 shows the decline in the number of tankers and the increase in utilization of tank barges in Great Lakes domestic waterborne commerce during the years 1972 through 1976. It should be noted that dry cargo vessel shipments exceeded 90 percent of the total Great Lakes domestic waterborne commerce during this period.

C. DOMESTIC TANKERS AND TANK BARGES AS PART OF THE TITLE XI PROGRAM

1. TANKERS (OIL AND CHEMICAL)

Tank vessels engaged in the domestic trade play a vital role in the United States economy as well as in the defense of the country in time of war. In the past 50 years domestic U.S. shipping has produced enormous economic benefits for the nation due to the employment within the shipping and allied industries, the taxes, balance of payments benefits, and the transportation services rendered.

However, of the domestic tankers currently engaged in domestic trade, only a small percentage receive government aid. As of the end of February 1978, there were 178 tankers engaged in domestic ocean trade. There are only 10 tankers in the domestic ocean trade (excluding the tankers chartered to the Military Sealift Command) receiving Title XI financial aid. A breakdown of the tankers receiving Title XI Government Aid that are eligible for domestic trade is given in Table II-12. In addition to the 178 tankers which are actively engaged in domestic ocean trade, there is a potential for 37 additional ships. These vessels are currently laid-up. chartered to Military Sealift Command, under construction, or engaged in the foreign trade, but receiving Title XI funding. Of the 37 it is likely that only 3 are under construction and some percentage of the 21 currently in the foreign trade would actually enter the domestic trade. Table II-13 is a listing of those ships that are eligible to receive Title XI financing.

Table II–11
U.S. GREAT LAKES DOMESTIC WATERBORNE COMMERCE BY VESSEL TYPE
(Thousands of Short Tons and Percentage of Total)

	1972		1973		1974		1975		1976	
DRY CARGO VESSEL	142,041	(92%)	156,777	(95%)	145,983	(94%)	127,420	(93%)	129,227	(92%)
TANKER VESSEL	6,769	(4%)	5,627	(3%)	5,139	(4%)	4,400	(3%)	4,147	(3%)
DRY CARGO BARGE	2,441	(2%)	347	(---)	2,021	(1%)	2,742	(2%)	3,937	(3%)
TANK BARGE	2,591	(2%)	2,392	(2%)	2,141	(1%)	2,526	(2%)	3,002	(2%)
TOTAL	153,842	(100%)	165,143	(100%)	155,284	(100%)	137,088	(100%)	140,313	(100%)

SOURCE: Domestic Waterborne Trade of the United States, 1972 – 1976, U.S. Department of Commerce, Maritime Administration.

Table II–12
SUMMARY OF TANK VESSELS ELIGIBLE FOR DOMESTIC TRADE THAT RECEIVE TITLE XI–GOVERNMENT AID

AREA OF EMPLOYMENT	NUMBER OF VESSELS
CURRENTLY ENGAGED IN DOMESTIC TRADE	
INTERCOASTAL	3
GULF COAST	3
ATLANTIC COAST	1
PACIFIC COAST	1
PUERTO RICO	2
SUBTOTAL	10
CURRENTLY IN FOREIGN TRADE	21
TIME CHARTERED (EXCLUSIVE OF MSC AND UNDER CONSTRUCTION)	4
CHARTERED TO MSC	8
LAID-UP	1
UNDER CONSTRUCTION	3
SUBTOTAL	37
TOTAL	47

SOURCE: Maritime Administration, 1978.

Table II–13

TANKERS (OIL AND CHEMICAL) RECEIVING TITLE XI FINANCIAL AID THAT ARE ELIGIBLE FOR DOMESTIC TRADE

OWNER	NAME	DWT (OIL/CHEMICAL)	AMT. OF MORTGAGE ($)	YEAR BUILT	TRADE
ALBATROSS TANK CORP.	ERNA ELIZABETH	33,200 (0)	8,903,000	'59	TC,MSC
AMERICAN TRADING CO.	WASHINGTON TRADE	41,600 (0)	10,325,000	'59	FOREIGN
EAGLE TERMINAL TANKER	EAGLE LEADER	37,350 (0)	10,200,000	'69	INTERCOASTAL
	EAGLE TRANSPORTER	37,250 (0)	10,200,000	'58	TC,MSC
	EAGLE CHARGER	26,500 (0)	7,875,000	'69	FOREIGN
	EAGLE COURIER	26,500 (0)	7,875,000	'58	FOREIGN
FALCON TANKERS, INC.	FALCON LADY	34,250 (0)	9,184,000	'71	TC,MSC
	FALCON DUCHESS	34,250 (0)	9,338,000	'71	TC,MSC
	FALCON COUNTESS	34,250 (0)	9,338,000	'72	TC,MSC
	FALCON PRINCESS (BOSTON CARRIERS, INC.)	34,250 (0)	9,338,000	'72	TC,MSC
INTERCONTINENTAL BULKTANK CORP.	OVERSEAS ALASKA	62,000 (0)	14,063,000	'68	CURRENTLY FOREIGN
	OVERSEAS ALICE	37,300 (0)	9,266,000	'70	TC,MSC
MANHATTEN TANKER CO.	MANHATTAN	114,500 (0)	20,925,000	'62	GULF
MONTICELLO TANK COMPANY	MONTICELLO VICTORY	47,700 (0)	11,686,000	'61	FOREIGN
MONTPELIER TANK COMPANY	MONTPELIER VICTORY	47,700 (0)	13,313,450	'62	FOREIGN
MT. VERNON TANK CO.	MT. VERNON VICTORY	47,000 (0)	11,858,000	'61	FOREIGN
MT. WASHINGTON TANK CO.	MT. WASHINGTON	47,000 (0)	12,313,450	'63	ATLANTIC COAST
NATIONAL TRANSPORT CORP.	VANTAGE DEFENCER	71,054 (0)	16,488,000	'59	FOREIGN
NAUTILUS PETROLEUM CARRIERS CORP.	SISTER KATINGO	33,100 (0)	9,606,000	'58	PACIFIC COAST

Table II–13 (Cont'd.)

OWNER	NAME	DWT (OIL/CHEMICAL)		AMT. OF MORTGAGE ($)	YEAR BUILT	TRADE
NEWPORT TANK CORP.	ACHILLES	41,200	(0)	10,792,000	'60	FOREIGN
NORTHWEST SHIPPING CORP.		89,000	(0)	14,800,000	UNDER CONST.	
OCEAN TRANSPORTATION CO.	OVERSEAS ULLA	37,750	(0)	10,500,000	'60	FOREIGN
	OVERSEAS ALEUTIAN	39,300	(0)	6,414,000	'53	FOREIGN
OCEAN TANKSHIPS CORP.	OVERSEAS VIVIAN	37,800	(0)	9,342,000	'69	FOREIGN
	OVERSEAS NATALIE	72,245	(0)	16,250,000	'61	FOREIGN
OVERSEAS BULKTANK CORP.	OVERSEAS VALDEZ	37,800	(0)	9,375,000	'68	TC,MSC
	OVERSEAS ARCTIC	61,440	(0)	14,107,000	'71	FOREIGN
	OVERSEAS JUNEAU	120,000	(0)	27,000,000	'73	GULF
OVERSEAS OIL CARRIERS, INC.	OVERSEAS JOYCE	48,000	(0)	11,500,000	'61	FOREIGN
PITTSBURGH PLATE GLASS	PUERTO RICO	34,400	(LPG)	20,650,000	'71	PUERTO RICO
PENN TANK CO.	PENN CHALLENGER	35,070	(0)	9,117,000	'60	FOREIGN
	PENN CHAMPION	37,250	(0)	10,325,000	'69	INTERCOASTAL
SABINE TOWING & TRANSPORTATION CO.	COLORADO	34,400	(0)	5,400,000	'72	GULF
SEA TRANSPORT CORP.	EAGLE TRAVELER	32,000	(0)	10,500,000	'59	FOREIGN
	EAGLE VOYAGER	32,000	(0)	10,500,000	'59	FOREIGN
SHIPCO 2295 INC.	ATIGUN PASS	165,000	(0)	75,460,000	'76	TC
SHIPCO 2296 INC.	KEYSTONE CANYON	165,000	(0)	76,625,000	'76	TC
SHIPCO 2297 INC.	BROOKS RANGE	165,000	(0)	73,434,000	UNDER CONST.	TC

Table II–13 (Cont.d.

OWNER	NAME	DWT (OIL/CHEMICAL)	AMT. OF MORTGAGE ($)	YEAR BUILT	TRADE
SHIPCO 2298 INC.	THOMSON PASS	165,000 (0)	75,047,000	UNDER CONST.	TC
SHIPMOR ASSOC. INC.	1st OVERSEAS CHICAGO	89,700 (0)	30,078,000	'77	TC
	2nd OVERSEAS NEW YORK	89,700 (0)	30,078,000	'77	TC
652 LEASING CO.	SOHIO INTREPID	80,000 (0)	17,800,000	'71	FOREIGN
653 LEASING CO.	SOHIO RESOLUTE	80,000 (0)	20,600,000	'71	LAID-UP
TRANSEASTERN SHIPPING CORP.	TRANSEASTERN	46,000 (0)	11,825,000	'59	FOREIGN
U.S. TRUST CO. OF N.Y.	NOTRE DAME VICTORY	80,000 (0)	19,000,000	'73	FOREIGN
WABASH TRANSPORT INC.	OGDEN WABASH	37,853 (0)	9,887,000	'69	PUERTO RICO
WILLIAMETTE TRANSPORT CO.	OGDEN WILLIAMETTE	37,853 (0)	9,887,000	'69	INTERCOASTAL

*NOTE: TC = TIME CHARTER
MSC = MILITARY SEALIFT COMMAND

SOURCE: Maritime Administration, 1978.

2. TANK BARGES (OIL AND CHEMICAL)

As of the end of June 1977 there were 117 tank barges that were receiving Title XI ship financing guarantees. These barges range in capacity from 10,000 to 100,000 barrels, carry a variety of oil products and chemicals, and vary in design from single skin to double skin, conventional and integrated. In addition to these barges being used for the domestic ocean, inland and Great Lakes trades to transport petroleum products and chemicals, there are a number of barges used for refueling larger vessels. Table II-14 provides a listing of those barges built during the years 1970 and 1977 in the domestic trade that are receiving Title XI financial aid.

Table II–14
BARGES (OIL AND CHEMICAL) ENGAGED IN THE DOMESTIC TRADE THAT RECEIVE TITLE XI FINANCIAL AID

OWNER	NAME OF VESSEL	NUMBER OF VESSELS	BARGE TYPE	CAPACITY	ORIGINAL PRICE/ AMOUNT OF MORTGAGE ($)	YEAR BUILT
ASPHALT BARGE CORP.	BARGE 3200 (2 tugs also)	1	RIVER TANK BARGE	30,300 bbl	197,000	'70
BILCON ASSOCIATES		1	OCEANGOING TANK BARGE	100,000 bbl	1,983,000	'74
CENTRAL MARINE CORP.	CBE's 138, 139, 172, 173, 323, 324 (2 tugs)	6	PETROLEUM BARGES– INLAND RIVER		3,012,500	'73
HANNAH BARGE LIMITED	OCEANGOING TANK BARGE	1		57,000 bbl	3,163,000	'76
HANNAH INLAND WATERWAYS CORP.	HANNAH 3601	1	OCEANGOING BARGE	36,000 bbl	823,000	'73
HANNAH BARGE LIMITED PARTNERSHIP		1	OCEANGOING BARGE	51,000 bbl	2,753,000	'75
INGRAM OCEAN SYSTEMS INC.	IOS 3301 (1 tug also)	1	OCEANGOING BARGE INTEGRATED	33,000 DWT*	6,333,000	'72
INGRAM RIVER EQUIPMENT COMPANY	IB 2701L, IB 3001 B, IB 1501 B, IB 2702 T	4	CHEMICAL BARGES		––	'74
	IB 20016, IB 2301 B, IB 1101 B, IB 20027	4	FUEL BARGES		2,012,000	'74
INGRAM TRANSPORTATION CO.	FUEL BARGES	16			10,838,000	'76
	FUEL BARGES	32			25,696,251	'76
INTER-CITIES NAVIGATION CORP.	BARGE OCEAN CITIES	1	OCEANGOING BARGES		4,544,000	'72

Table II–14 (Cont'd.)

OWNER	NAME OF VESSEL	NUMBER OF VESSELS	BARGE TYPE	CAPACITY	ORIGINAL PRICE / AMOUNT OF MORTGAGE ($)	YEAR BUILT
INTERCITY BARGE LINE	NO. 3203	1	RIVER BARGE	30,000 bbl	179,000	'70
	NO. 3205	1	RIVER BARGE	30,000 bbl	179,000	'70
INTERSTATE MARINE TRANSPORT CO.	INTERSTATE 37	1	BARGE OCEAN	35,000 bbl	4,330,000	'75
	INTERSTATE 38	1	BARGE OCEAN	35,000 bbl		
	OCEAN 155	1	BARGE OCEAN	160,000 bbl		
INTERSTATE MARINE TRANSPORT CO.	BARGES	2		35,000 bbl	4,330,000	'75
	BARGE	1		35,000 bbl		
	BARGE	1		160,000 bbl		
INTERSTATE MATERIALS TRANSPORT CO.	INTERSTATE 35	1	BARGE	35,000 bbl		
	INTERSTATE 36	1	BARGE	35,000 bbl		'75
MORAN ATLANTIC TOWING CORP.			TANK BARGES	64,000 bbl		'75
NMS CHEMICAL CORP.	BARGE NO. 3201	1	PETROLEUM BARGES–RIVER	30,000 bbl	197,000	'72
	BARGE NO. 3202	1			199,000	'72
	BARGE NO. 3203	1			200,000	'72
NATIONAL MARINE SERVICE	BARGES	15			4,637,509	'77
NATIONAL MARINE SERVICES, INC.	NMS BARGE NO. 3100		RIVER BARGE (D.S.)	3,000 T**	1,400,000	'72
	NMS BARGE NO. 3101		RIVER BARGE (D.S.)	3,000 T**		
	NMS BARGE NO. 1400		RIVER BARGE (D.S.)	1,300 T**		
	NMS BARGE NO. 1401		RIVER BARGE (D.S.)	1,300 T**		

* DWT = DEAD WEIGHT TONS
** T = TONS
D.S. = DOUBLE SKIN
bbl = barrels

SOURCE: Maritime Administration, 1978.

CHAPTER II - REFERENCES

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2 Economic Significance of the Jones Act, prepared for the Shipbuilders Council of America, Washington, D.C., April 1975. Jacob J. Kaplan Consultant, International Finance and Economics.

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6 Transportation of Liquefied Natural Gas, Congress of the United States, Office of Technology Assessment, Washington, D.C., September 1977, p. 7.

7 Federal Power Commission, Recommendation to the President, Alaskan Natural Gas Transportation System (Washington, D.C., Federal Power Commission, May 1, 1977), p. I-44.

8 Big Load Afloat, U.S. Domestic Water Transportation Resources. The American Waterways Operators, Inc., 1973.

9 Joint Marad/USCG Tank Barge Study, October 1974.

CHAPTER III
DESCRIPTION OF THE MARINE ENVIRONMENT

INTRODUCTION

The marine environment may be grouped into two major domains: the coastal ocean and the open ocean. The coastal ocean includes the waters of the continental shelves, estuaries, and adjacent wetlands and lagoons. The open ocean lies seaward of the continental shelves and is not significantly affected by continental boundaries or the ocean bottoms. A third aquatic domain is navigable freshwater rivers and lakes.

A. OPEN OCEAN (1,2)

Beyond the continental shelves, the open ocean is relatively unaffected by the continental boundaries. Over most of the open ocean, warm surface waters are separated from the cooler deep waters by what is known as the pycnocline, a rapid increase in density that more or less separates surface ocean waters from deeper waters. The deeper waters are known to move sluggishly after forming in the polar regions (primarily the Antarctic) and to return to the surface about 600 to 1,000 years later.

Away from the continents that interrupt surface water movements, ocean currents are primarily directed east-west. Only in the areas of the continental boundaries are the currents deflected to the north or south forming major boundary currents. Open ocean currents generally move surface waters at speeds of a few miles per day. In the boundary currents such as the Gulf Stream, the waters move at speeds of ten to a hundred miles per day.

Winds blowing across the ocean set the surface waters in motion. In the open ocean where tidal currents are relatively weak, these wind drift currents account for about 40 percent of the surface currents.

1. OCEANIC WATER QUALITY CHARACTERISTICS

Due to the major oceanic circulation patterns, oceanic water masses are established possessing similar water quality characteristics. These water masses are established due to the major oceanic circulation patterns, as illustrated in Figure III-1. Although these masses are loosely defined, they do afford a method for descriptive analysis since they possess similar water quality as well as major marine specie assemblages.

As presented in Table III-1, the principal controlling parameter of the water masses is the temperature component. Although salinity, oxygen, and nutrients do vary within the respective masses, the temperature component has the most significant effect on determining the marine community distribution within the respective water mass.

Within the major masses as previously discussed the near shore environment can be significantly modified by coastal features. These smaller environmental and habitat differences produce changes in the marine populations along the east and west coasts.

B. COASTAL OCEAN (1,2)

The coastal ocean is the water adjacent to the shore; there the adjacent land boundary, freshwater runoff from the land, and local atmospheric conditions contribute significantly to the movement and mixing of the waters. The width of the coastal ocean varies, and its outer boundary is not well defined. It may be quite narrow along coasts where the continental shelf is narrow and where oceanic conditions and "permanent" currents come close to shore. Conversely, where the continental shelf is wide, the coastal ocean may be tens or even hundreds of miles wide. The coastal ocean does not, however, always coincide with the continental shelf. Where the shelf is very narrow, the coastal ocean may extend beyond the edge of the shelf, or where the shelf is very wide, the coastal ocean may extend out from shore for only a part of the shelf width.

Although making up only 12.5 percent of the ocean surface, coastal ocean waters are vitally important. Heavily used for waterborne commerce,

Figure III–1 NORTH AMERICAN OCEANIC WATER MASSES

ADAPTED FROM: Odum, H.T., B.J. Copaland, E.A. McMahan, Coastal Ecological Systams of tha Unitad States, Tha Conservation Foundation, 1974.

Table III–1
ENVIRONMENTAL PARAMETERS OF THE ESTUARINE ZONES OF THE UNITED STATES

Environmental factor	*North Atlantic*	*Middle Atlantic*	*Chesapeake Bay*	*South Atlantic*	*Caribbean*	*Gulf of Mexico*	*Pacific Southwest*	*Pacific Northwest*	*Alaska* (1)	*Pacific Island*
Continental Shelf Width Range (Kilometers) Bottom Type	240–320 Irregular, Rocky	80–160 Smoothly Sloping, Lagoon off MJR	Not Applicable	50–110 Smoothly Sloping	5–15 E< FLA Puerto Rico, Virgin Islands 190-N of Florida Keys	105–225 Smoothly Sloping	3–32 Average about 10	15–60, with Indentations on the Outer Edge	48–240 on SE & S Coast 400 on W Coast	O, Volcanic Island Rising From S
Ocean Currents (2) Influenced By:	Labrador Current	Labrador Current	None	Gulf Stream	Gulf Stream	Waters Forming Gulf Stream	California Current	California-Aleutian Current	Alaska Current	Mid-Pacific Circulation
Temperature (°C)										
Mean	8	12	42	22	27	23	16	13	6	25
Summer	18	23	27	31	31	31	21	19	13	27
Winter	0	2	33	10	22	12	13	7	−1	23
Salinity (%)										
Mean	3.03	3.15	1.37	3.55	3.57	3.23	3.36	3.08	3.19	3
Dry Season	3.1	3.18	1.60	3.60	2.63	3.70	3.38	3.25	3.21	3
Wet Season	2.9	3.13	1.10	3.25	3.49	3.03	3.33	2.85	3.12	3
Coastline Structure	Rocky, Very Irregular, Many Embayments	Smooth, Many Large Embayments	Very Irregular Extensive Marshes on East Side	Smooth, Low Lying, Extensive Marshes	Irregular Mangroves, Coral & Rocks	Smooth, Low Lying with Barrier Islands, Marshes	High Land Close to Shore, Bluffs & Beaches	High Land Close to Shore, Bluffs & Beaches	All Glaciated, Irregular Except in NW	Steep Irregular with Beaches
River Flow										
Runoff Per Kilometer of Tidal Shoreline (Cubic meters per second)	.28	.27	.27	.28	.05	.92	.48	1.4	No Data	No Data
Number of Major River Basins	5	6	6	12	0	21	8	9	16	0
CBX.02832 = CMS Total Runoff (CFS)	2040	3,000	2,260	4,360	330	22,600	2,360	10,400	No Data	No Data
Sedimentation	No Data: Sedimentation not Severe Problem Great									
Quantity of Suspended Load (1,000 tons/yr)	Amount of Rock 15,300		8,640	58,100	No Data	362,600	24,000	127,000	No Data	No Data
Climate (3)										
Temperature (°C)										
Mean	7	12	4	19	24	21	16	13	10	24
Summer	27	29	31	33	32	33	24	26	24	28
Winter	−11	−4	−1	4	18	7	12	8	−15	26
Precipitation (cm)										
Total in × 2.540 = cm	109	107	112	127	117	140	30	102	142	61
Snow, Ice	183	41	58	0	0	0	0	23	227	0
Tide (3)										
Type	Equal Semidiurnal	Equal Semidiurnal	Equal Semidiurnal	Equal Semidiurnal	Equal Semidiurnal	Diurnal	Unequal Semidiurnal	Unequal Semidiurnal	Unequal Semidiurnal	Unequal Semidiurnal
Mean Range (meters)	3.0	1.5	0.7	1.5	0.7	0.7	1.5	2.3	7.0	0.7

(1) Data are given for Southeast and South Coasts only
(2) Data are Typical Near-Coastal Values for the Region, except for Chesapeake Bay, where Data are for the Middle of the Bay
(3) Data are for a Point Typical of the Region
Reference: The National Estuarine Inventory

Data Source: U.S. Coast and Geodetic Survey, U.S. Geological Survey, U.S. Weather Bureau

SOURCE: Marine Pollution and Sea Life, FAO 1972, Estuarine and Coastal Pollution in the United States T.A. Wastler, L.C. Wastler

coastal waters are also used for recreational fishing and boating, commercial fishing, and waste disposal. Despite these heavy and often conflicting uses, coastal waters are still the most productive part of the world ocean; an estimated 90 percent of the world's marine food resources are harvested there.

The principal ecosystems which could be affected by this program are the coastal waters along the domestic ship routes, and navigable inland waterways. Due to the broad scope of the program only general environmental descriptions will be discussed for the principally utilized shipping routes. The principal shipping zones for domestic oceanic trade traverse along the: western Pacific coast off Alaska, Canada, Continental U.S. and Mexico, the Gulf of Mexico, and along the east Atlantic Coast. The description of the marine environment is divided into the bathymetric physiographic settings, major circulation patterns, general water mass oceanographic features, major tropic levels and species, commercial species and coastline resources.

1. MARINE PHYSOGRAPHIC PROVINCES (3,4)

The submerged nearshore coastal environment along the U.S. Domestic oceanic trade routes varies in a similar fashion as their landward components. These characteristics, as illustrated in Figure III-2 and tabulated in Table III-1, range from broad continental shelf areas as found surrounding the Gulf Coast and eastern seaboard to the deep trenches immediately off the west coast of Central America. The differences in the bathymetric provinces form a significant environmental factor controlling the marine and estuarine flora and fauna found in that respective region. The principal features of the physiographic provinces which control the marine communities are the controlling depths and bottom composition of rocks, sand, silts, shell and reefs. These two features interact with other oceanographic and environmental parameters to provide habitat controls for the marine community development. Although the principal amount of coastwise commerce traverses over the continental shelf area along the Pacific coast routes, due to the small extent of the shelf area, the continental slope and abysal plains areas are principally traversed. Shipping routes to the Hawaiian Islands traverse the open Pacific ocean for 3,200 miles from the west coast.

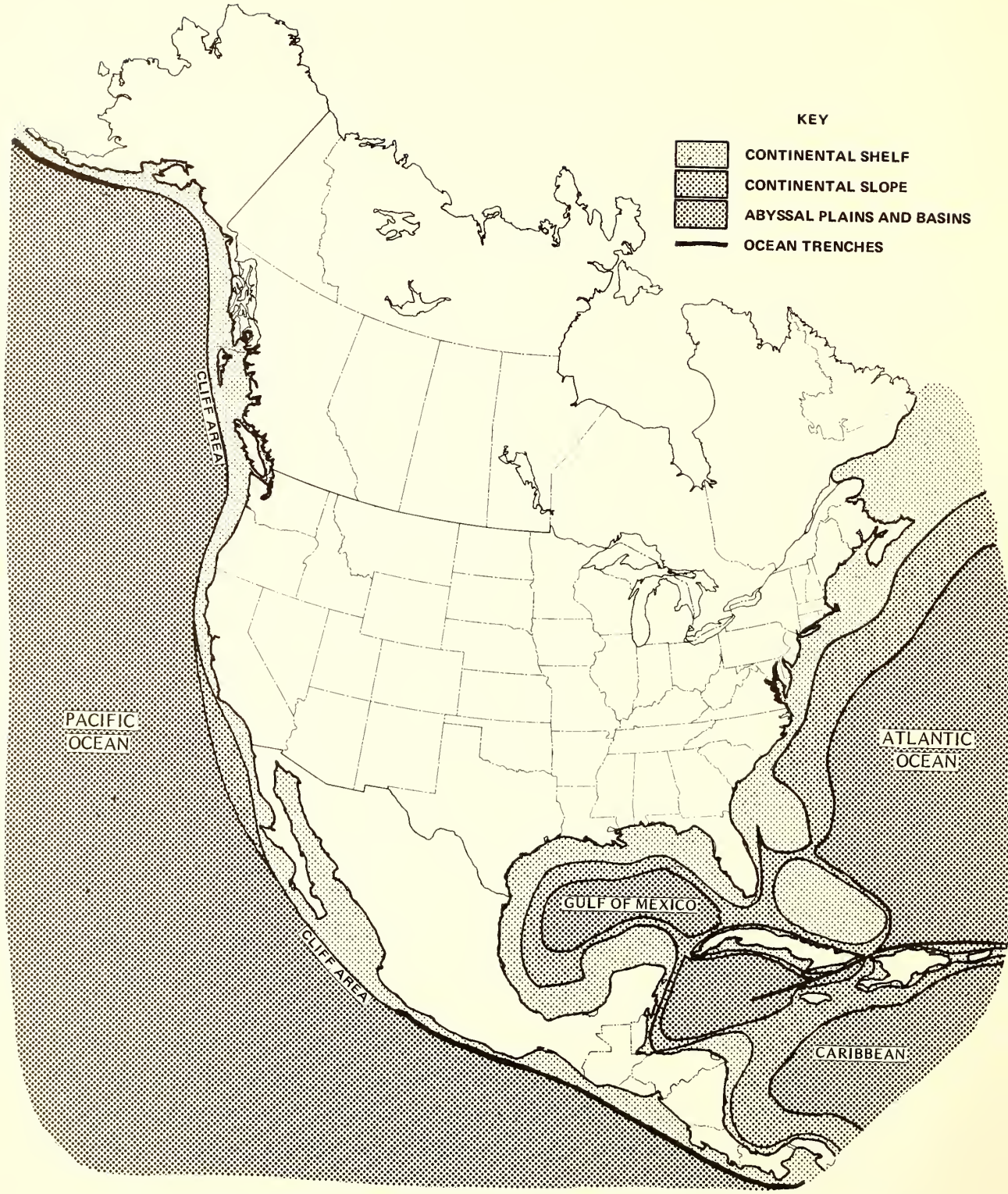

Figure III–2 BATHYMETRIC PHYSIOGRAPHIC PROVINCES

SOURCE: Adepted from: Nationel Atlas, United States Geological Survey, 1970
World Map, Serias 1142, U.S. Depertmant of Defanse

2. MAJOR COASTAL CIRCULATION PATTERNS

The large scale circulation of water masses surrounding the North American Continent is the major environmental driving force controlling marine assemblages and dynamics. The worldwide circulation and mass movement as illustrated in Figure III-3, within the North American coastal zones are the clockwise north Pacific current in the Pacific Ocean, and the north Equatorial and Gulf Stream current in the Caribbean, Gulf of Mexico, and Atlantic seaboard. Close to shore these major currents can form counter currents and gyres as the Alaska Gyral in the Gulf of Alaska, Davidson Current off California, and the Middle Atlantic and Carolinean Current off the Atlantic Coast. Each of these currents has differing physical and chemical characteristics which greatly influence marine and estuarine ecosystems. (1,2,5)

Within the immediate coastal zone existing one to five miles offshore, these major circulation patterns and cells become heavily influenced by wind induced stresses, thermoclines, salinity changes, bottom roughness, freshwater inputs, and tidal and estuarine movements. For any given location along the coasts these variables would control the currents in differing degrees and makes generalizations meaningless.

Vessels traversing the Pacific coastal routes would be more heavily under the influence of the major water masses whereas the vessels travelling along the inshore coastal shelf area off the gulf and east coasts would likely be under the influence of the major currents as well as the modified current induced by the more prevalent inshore current stresses.

Coastal ecosystems along the periphery of the North American Continent vary from Rocky seafronts to marshland. As illustrated in Figure III-4, the predominant coastal ecosystems are Rocky Seafronts and High Energy sandy beaches. Although the physical appearance of a coastal ecosystem may be similar from one area of the continent to another, the physical and chemical component to the water mass greatly influence the biographic distributions of the species and organisms.

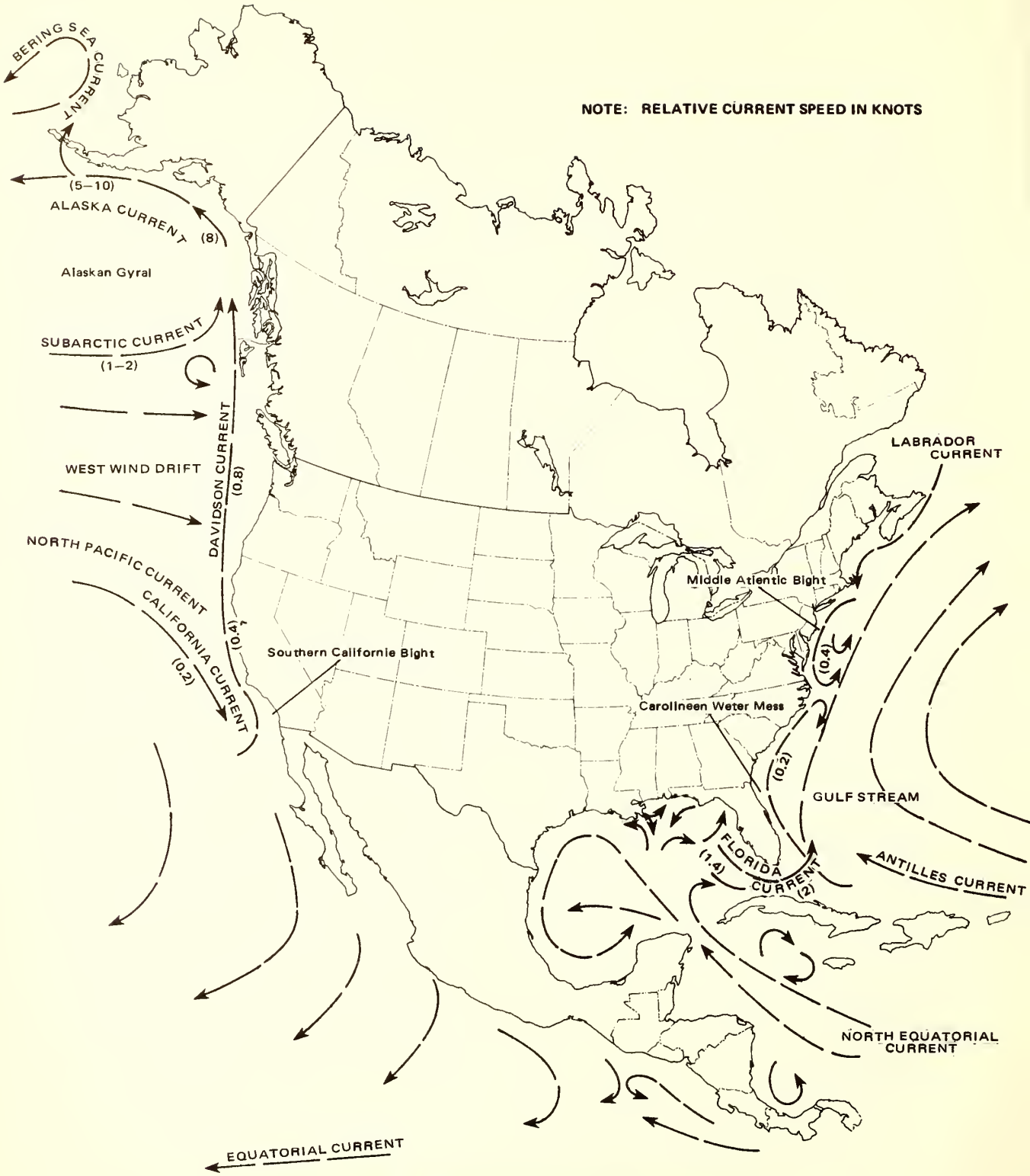

Figure III–3 ANNUAL NET OCEANIC CURRENTS

SOURCE: Adapted from: Pierce, Gordon R., Oceenography, Oxford University Press, 1977
Sverdrup, Johnson end Fleming, Oceens, Prentiss Hall 1942
Northern Gulf of Alaske, Dreft EIS, BLM, 1975. Nationel
Atles, United Stetes Geological Survey, 1975.

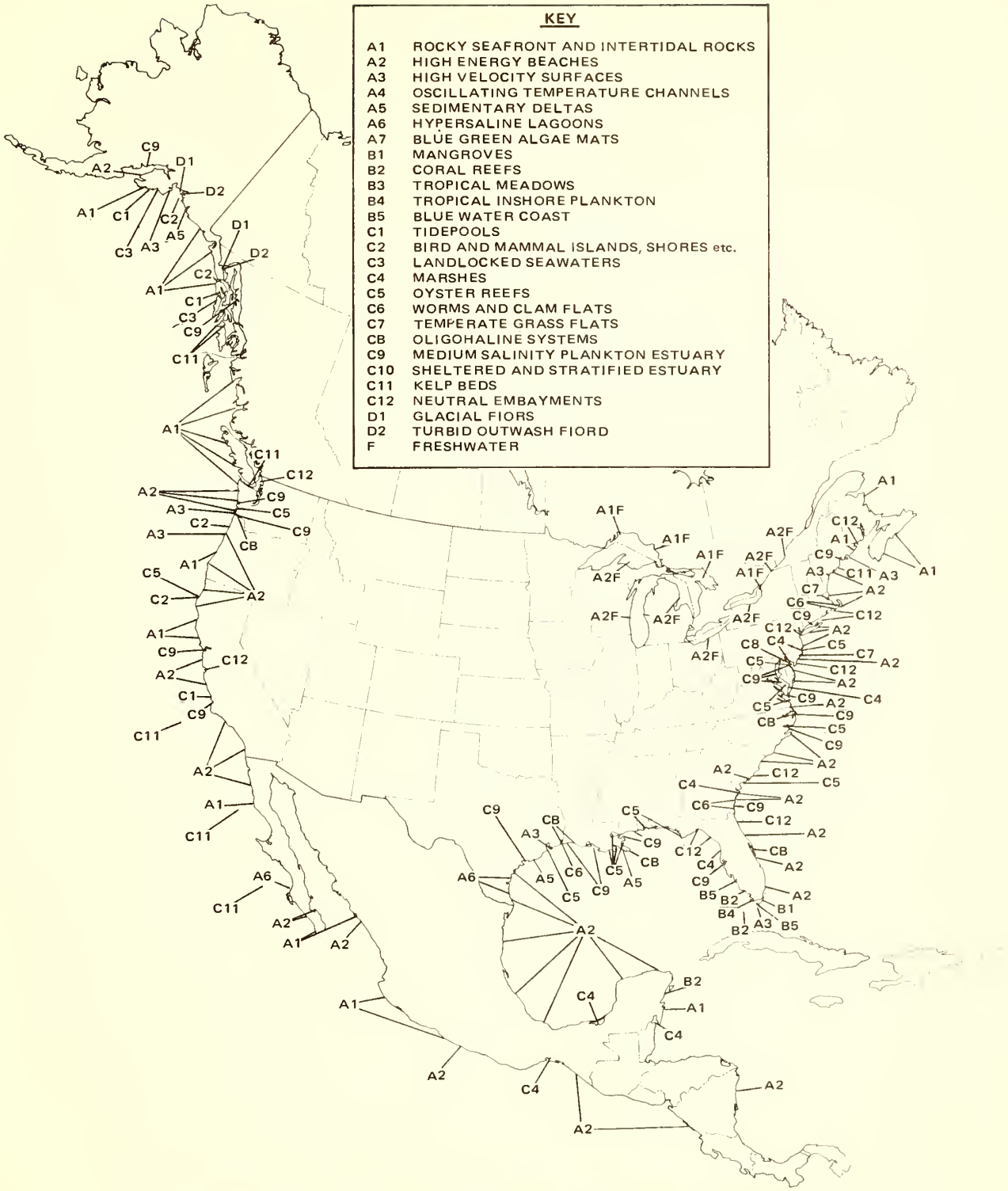

Figure III–4 GENERAL COASTAL ECOLOGICAL SYSTEMS

SOURCE: Adapted from: Odum, H.T., B.J. Copeland, E.A. McMahan, Coastal Ecological Systems of the United States, The Conservation Foundation, 1974.

The coastal ecosystems form an important nursery and feeding area for the offshore assemblages. For this reason the respective populations are controlled by the physical coast-front environment and the offshore populations.

The distribution of the principal migrating commercial species utilizing these coastal systems is shown in Figure III-5. An analysis of the important commercial species utilizing these waters emphasizes the importance of maintaining the quality of the coastal ecosystems.

C. INLAND WATERWAYS AND GREAT LAKES (FRESHWATER) (3)

Vessels transporting bulk cargoes (primarily tank barges) enter freshwater rivers and inland waters for the purpose of loading and discharging these cargoes. Life in freshwaters is influenced, as in the ocean environment, by water temperature, dissolved oxygen, pH, color, turbidities, total dissolved solids, total alkalinity, nutrients and mineral composition.

The nearshore zone of large deep lakes such as the Great Lakes is the most important portion from the standpoint of man. Not only is it the zone that is most used by man (for example, as a source of water supply for domestic, industrial, and cooling water uses and as an area for fishing, boating and swimming), but it is also a biologically productive region. One basic reason for the natural high productivity of shallow water is the presence of a substrate within the lighted surface zone where photosynthesis can take place. Also, nutrients are continually recycled from the bottom sediments back into the water column due to vertical mixing processes.

River environments differ from lakes in the following fundamental respects: (1) depth is small compared to lakes; (2) the water is generally confined to a relatively narrow channel; (3) the volume of water flows in one direction; (4) streams increase their length, width and depth with increasing age; and (5) eroded materials are transported downstream with no opportunity for return.

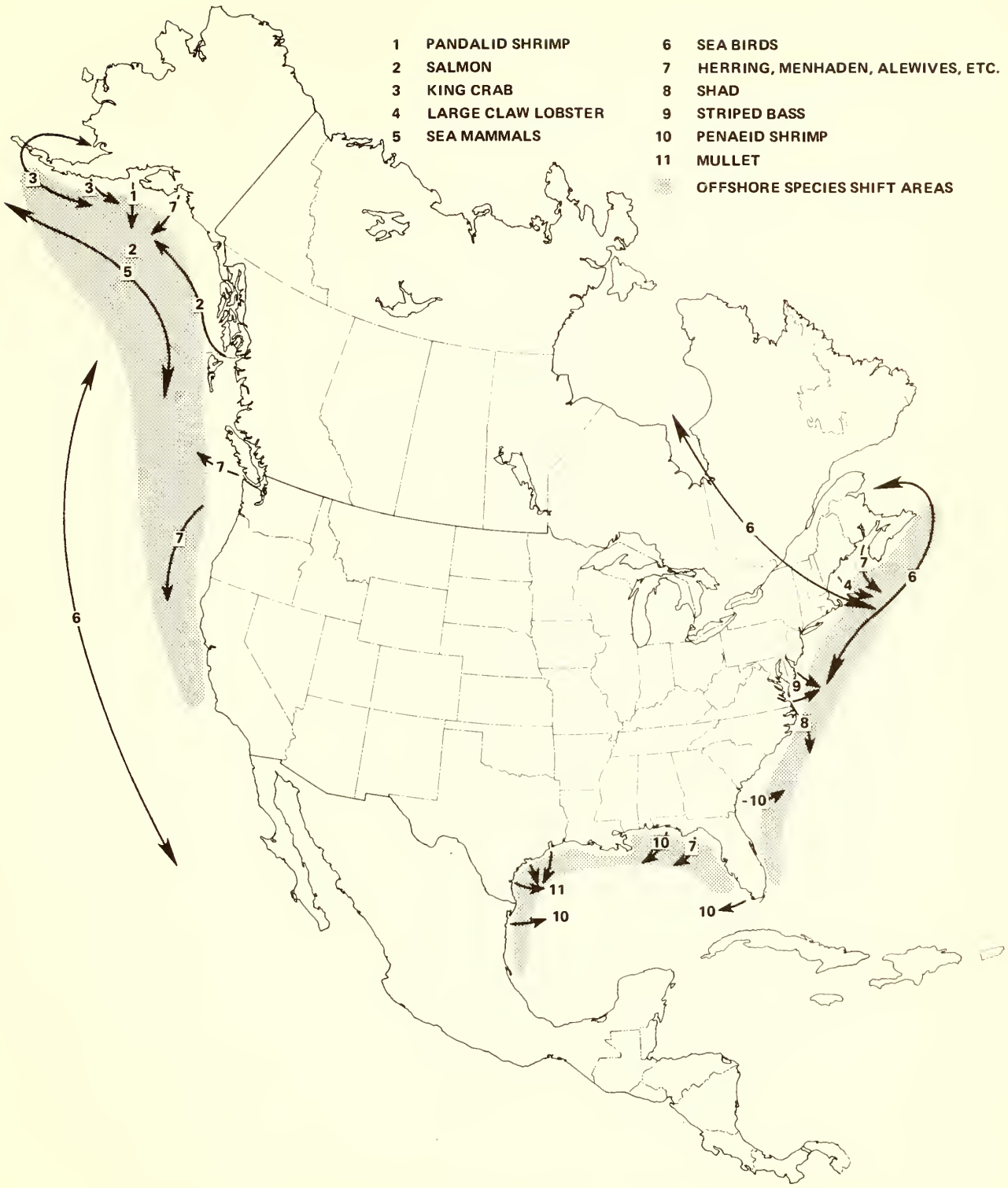

Figure III–5 SEASONALLY SHIFTING STOCKS OF THE NORTH AMERICAN COASTAL ZONES

SOURCE: Adapted from: Briggs, J.C., Marine Zoogeography, McGraw Hill, 1974.

River environments exhibit all intergrades from the very swift rushing waters in narrow channels to situations which are relatively lakelike. This range of conditions is reflected in the biota, which varies from the distinctively characteristic organisms of falls and rapids to lake-like systems.

D. GREAT LAKES SYSTEM

The Great Lakes System is approximately 2,000 miles long and has a surface area of 95,000 square miles. The volume of the Great Lakes System constitutes the earth's largest freeflowing freshwater resource. The overall lake and river system constitutes the largest system within the U.S. and has an annual outflow of 237,000 cubic feet per second. As illustrated in Table III-2, the respective dimensions of the lakes varies considerably as does the aquatic habitat. The aquatic habitat varies from a cold-water fishery to a warm-water fishery throughout the span of the Great Lakes and the St. Lawrence River System.

The quality of the surface water in lakes Ontario, Huron, Superior, and Michigan is generally high with some serious problems being experienced in the surrounding major metropolitan and industrial areas. Lake Erie, as a result of many factors including its shallowness and large number of metropolitan areas surrounding it, has the poorest water quality. Despite the poor water quality, Erie is still the leader in fish production. Recent water pollution control efforts made within the past decade are slowly improving the lake's water quality, consequently, the aquatic resources are demonstrating a regrowth.

The development of the Great Lakes is principally due to the scouring action and deposition of the multiple glacial surges proceeding across the region. Due to the lake's large depths a dimictic circulation pattern is exhibited. The lakes become stratified during the summer with negligible mixing occuring into the colder water layer located beneath the thermocline. Within the water layers above the thermocline, the nutrients and oxygen circulate due to the wind driven currents. During the spring and fall, the temperature differential between the two water layers

Table III–2
GREAT LAKES ENVIRONS

GREAT LAKE	LAKE AND SHORELAND DESCRIPTION	FISHERY
LAKE SUPERIOR	– LARGEST AND NORTHERNMOST GREAT LAKE – MOST RUGGED, UNINHABITED AND INACCESSIBLE SHORELANDS – SHORELANDS ARE OF PRIME RECREATIONAL VALUE	– 16% OF TOTAL GREAT LAKES FISHERY PRODUCTION – LAKE TROUT, WHITEFISH, LAKE HERRING DOMINANT SPECIES – SPORT FISHERY: SMELT, PERCH, SUCKERS, PANFISH, NORTHERN PIKE, WALLEYE, BASS – SALMONID FISHERY: LAKE TROUT; COHO AND CHINOOK SALMON; RAINBOW, BROWN, BROOK, AND STEELHEAD TROUT
LAKE MICHIGAN	– TOTAL SHORELINE LENGTH IS 1,362 MILES – SHORELINE ALONG WISCONSIN, ILLINOIS, INDIANA, MICHIGAN STATES – CONTAINS LARGEST EMBAYMENTS – CONTAINS LEAST NUMBER OF ISLANDS AND ISLAND GROUPS – SANDDUNES, VULNERABLE ERODIBLE BLUFF AREAS – VALUABLE MARSHLANDS IN GREENBAY AND BIG AND LITTLE BAYS DE NOC	– YELLOW PERCH, SMELT, SUCKERS, SMALLMOUTH BASS, NORTHERN PIKE, WALLEYE AND ASSORTED PANFISH – SPORT FISHERY: OVER 1,700,000 ANNUALLY OF SALMONIDS – SALMONIDS: COHO AND CHINOOK SALMON, RAINBOW TROUT, LAKE TROUT, BROWN AND BROOK TROUT
LAKE HURON	– SECOND LARGEST LAKE – SEPARATED FROM LAKE MICHIGAN BY STRAITS OF MACKINAC – MAJORITY OF SHORELINE UNDER JURISDICTION OF CANADIAN PROVINCE OF ONTARIO – SAGINAW BAY MOST SIGNIFICANT FISH AND WILDLIFE AREA BECAUSE OF WETLANDS	– WALLEYE, LAKE WHITEFISH, LAKE TROUT – SPORT FISHERY: SALMON, RAINBOW TROUT, BROWN TROUT, STEELHEAD TROUT

Table III–2 (Cont'd)
GREAT LAKES ENVIRONS

GREAT LAKE	LAKE AND SHORELAND DESCRIPTION	FISHERY
LAKE HURON (Continued)	– SHORELINE MAINLY ROCK AND BOULDER SHORE – SANDY BEACHES FROM SAND POINT IN OUTER SAGINAW BAY TO NORTHERN HURON COUNTY	
LAKE ERIE	– SHALLOWEST MAXIMUM DEPTH OF ALL GREAT LAKES (210 FEET) – 30 FEET DEPTH CONTOUR 1 MILE FROM SHORE – GREAT WATER LEVEL FLUCTUATIONS – STRONG WINDS LOWER WATER LEVEL AT ONE END 8 FEET AND RISE SEVERAL FEET AT OTHER END – 115 MILE LONG WATERWAY DIVIDES UPPER GREAT LAKES FROM LOWER LAKE ERIE – SHORELINE RANGES FROM WETLANDS, LOW ERODIBLE BLUFFS TO ERODIBLE PLAIN SHORE	– WALLEYE, YELLOW PERCH, WHITE BASS, CHANNEL CATFISH – SPORT FISHERY: YELLOW PERCH, WHITE BASS, CHANNEL CATFISH, WALLEYE, SMALLMOUTH BASS
LAKE ONTARIO	– EAST-WEST SHORELINE: BLUFFS OF GLACIAL MATERIAL FROM 20 TO 60 FEET HIGH, NARROW GRAVEL BEACHES BORDERING THE BLUFFS – DRUMLINS AND DUNES SEPARATED BY MARSH AREAS ALONG SHORELINE FROM SODUS BAY EAST TO PORT ONTARIO – DUNES AND BARRIER BEACHES 10 MILES NORTH OF OSWEGO-JEFFERSON COUNTY LINE THEN ROCKY SHORE NORTH TO ST. LAWRENCE RIVER	– VERY LITTLE COMMERCIAL FISHING – SPORT FISHERY: SMALLMOUTH BASS, YELLOW PERCH, BROWN BULLHEAD, NORTHERN PIKE, ROCK BASS, COMMON BLUEGILL, SUNFISH, LARGEMOUTH BASS, WHITE PERCH, WHITE BASS, BLACK CRAPPIE, CARP, CHANNEL CATFISH, AMERICAN EEL, FRESHWATER DRUM, WALLEYE

SOURCE: Adapted from: Great Lakes Basin Framework Study, Great Lakes Basin Commission, 1975.

diminishes and some deep circulation occurs as the thermocline diminishes. During the winter, the four months of ice cover limits navigation and the next wind driven circulation pattern in the water column.

The Great Lakes System does provide a stopover area for the mid-America Waterfowl Flyway. During the spring and fall migration, the protected bays and adjacent wetlands provide a valuable habitat.

E. INLAND WATERWAYS ENVIRONMENT

Since the principal inland natural waterways are the Mississippi and the Ohio rivers, they were selected for a discussion of the inland waterway environment.

1. MISSISSIPPI RIVER

The navigable portion of the Mississippi River as illustrated in Figure II-3 is principally composed of the Upper Mississippi, Lower Mississippi, Illinois Waterway, and the Ohio River System sections. The overall basin comprises 40 percent of the continental U.S. land area. The river is the world's second longest, has the third largest drainage area and is ranked seventh in annual discharge.

2. LOWER MISSISSIPPI RIVER

The Lower Mississippi River begins at the confluence of the Ohio with the main stem and proceeds to the Head of the Passes at the Gulf of Mexico. The river throughout this reach has been extensively levied, carries a significant silt load and is used extensively for the disposal of municipal and industrial wastewater. These factors have produced a stressed environment with greatly reduced water quality and aquatic ecosystems within the main channel area. Within the lower Mississippi these pollution levels have drastically reduced the commercial fishing potential of the river. Although the main stream has a lowered aquatic resource value the tributaries feeding the river and the extensive estuarine nursery area surrounding the rivers, mainstem, bayous and drainage ways constitute valuable habitat and nursery areas.

The annual flows into the Gulf of Mexico are approximately 611,000 cubic feet per second when the diverted flow into the Atchafalaya drainage is considered. Average water velocity through this reach is approximately 2 miles per hour. Spill studies conducted on the lower Mississipi River indicate that the spill would spread laterally at 250 feet per mile. Under these conditions a spill of neutral buoyancy would be diluted 10,000 times within the first half hour of river travel.

3. UPPER MISSISSIPPI RIVER

The Upper Mississippi River has not been as extensively developed as the lower river; consequently, the aquatic environment and the water quality is higher than the Lower River. In contrast to the levied banks of the lower river, the Upper Mississippi has an extensive border of channels, sloughs and wetlands which have been integrated into the Upper Mississippi River Wildlife and Fish Refuge and the Mark Twain National Wildlife Refuge. These two areas, numerous smaller wildlife refuges, and the high quality rivers entering the mainstream provide a broad and valuable habitat for aquatic and waterfowl resources.

Commercial Fishery landings in the Upper Mississippi Basin are high and reflect the relative value of the warm water fishery. The mainstream and its borders provide valuable recreation areas for fishing, hunting, and boating activities.

Wetlands along the Mississippi River provide a major route of the Mid U.S. waterfowl flyway and provide valuable habitat for the waterfowl population which resides all summer in the area. The river also supplies water for municipalities along its banks. The average flows at St. Louis are approximately 175,000 cubic feet per second with stream velocities varying from 2.5 to 7.5 feet per second depending on the river stage.

4. OHIO RIVER

The 981 mile navigable portion of the Ohio River from Pittsburgh, Pennsylvania to Cairo, Illinois falls 429 feet. The navigability of the river is controlled by 19 high lift locks and dams. The navigable river

width varies from one-half mile to 4 miles wide. The mean monthly discharge ranges from a high of 20,000 cubic feet per second in March to a low of approximately 3,000 cubic feet per second in September. The water quality of the Ohio is impacted with acid mine drainage, and large industrial and municipal discharges. These discharges have caused fish kills and affected the aquatic resources of the mainstream. Even with the elimination of fish kills, the more subtle changes causing taste and odor problems in the fish and other changes in the aquatic resource food chains will still prevail. With the potential increases in coal development and coal powered power plants, the water quality problem areas would be expected to remain.

Due to water pollution, fish tainting, and market trends, the once-flourishing commercial fishery on the Ohio has drastically diminished. While the commercial fishing interests have diminished, the waterborne usage for sport fishing and hunting has increased. The commercial species most usually taken are Buffalo carp, catfish, paddlefish and sturgeon.

The Ohio and Mississippi rivers constitute a waterfowl flyway for birds proceeding southward from Indiana and Ohio.

CHAPTER III - REFERENCES

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4. U.S. Interior Department, Draft Environmental Impact Statement Proposed 1975 OCS Oil and Gas General Lease, Offshore Texas, (DES 74-82), August 27, 1974.

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CHAPTER IV

ENVIRONMENTAL IMPACT OF TITLE XI TANK VESSELS ENGAGED IN THE DOMESTIC TRADE

This chapter discusses the potential environmental impacts generated by bulk liquid domestic waterborne commerce of the type that could be funded under the Title XI Program. The major subjects discussed are: tank vessel pollution, (oil, chemical and others) spill probability and risk, potential economic impacts and the effects of port and harbor development.

Tankships and barges may be classified into two groups: (1) crude oil carriers, and (2) those that carry petroleum products, chemicals and liquefied gases. These are not fixed groups however, since vessels may shift from one trade to another as transportation requirements change. The current patterns of tanker utilization have evolved over the years as a result of economic factors, refinery locations, and prevailing trade patterns. Figure IV-1 illustrates the location of refineries and oil terminals near the navigable waterways of the United States. It gives some indication as to where domestic oil and petro-chemical trade may take place along the U.S. coastline and the navigable inland waterways.

In general, larger tankers (over 100,000 deadweight tons) are used for carrying crude oil and smaller tankers (under 40,000 deadweight tons) are used to transport chemicals and refined products. On occasion small tankers carry crude oil in U.S. waters due to draft limitations in U.S. ports. Intermediate sized ships (40,000 to 100,000 DWT) are often used to carry either crude oil, residual fuel oils or chemicals resulting from the refining process.

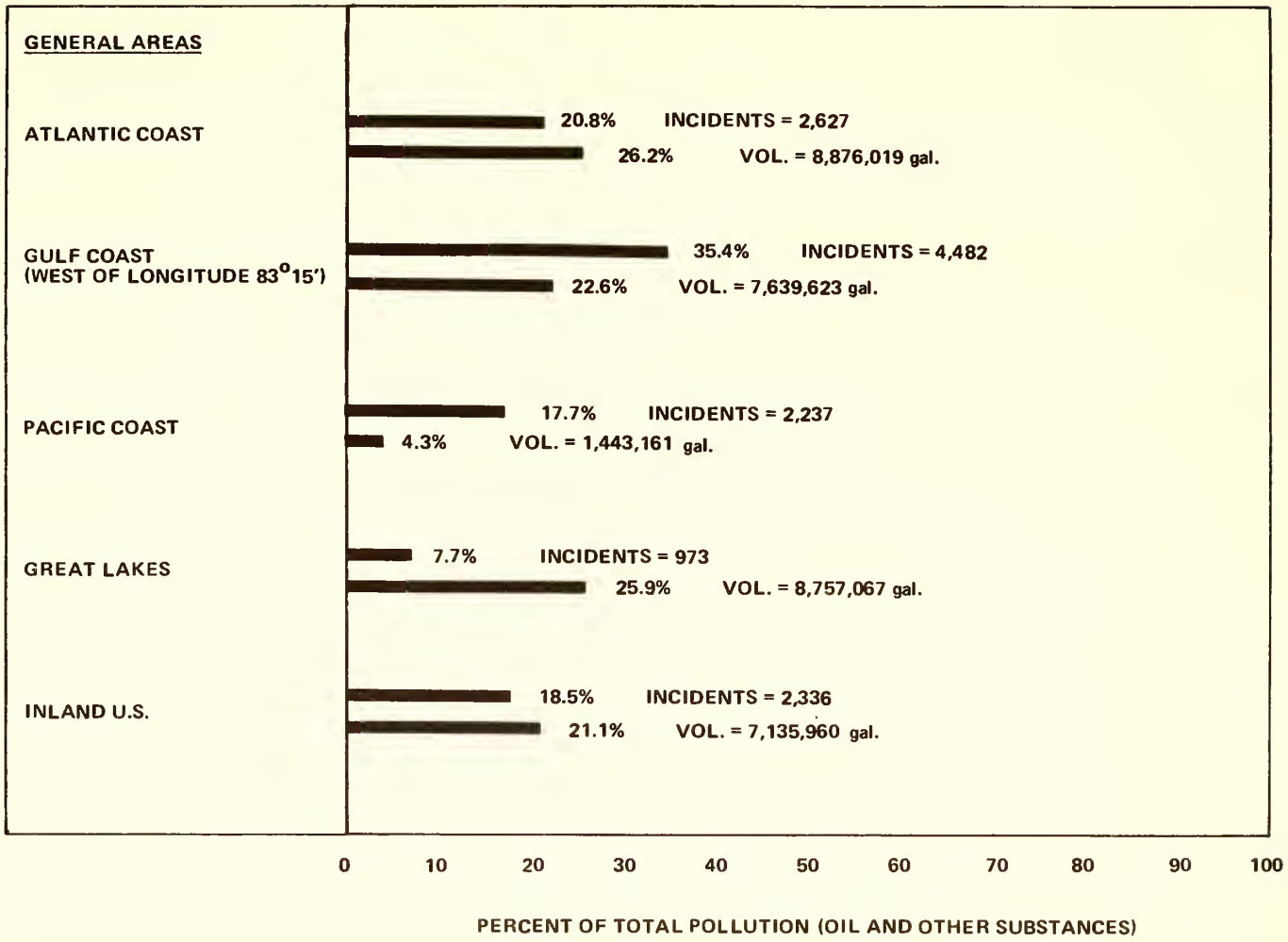
A OVERVIEW OF TANK VESSEL POLLUTING INCIDENTS (1)

During the calendar year 1976, approximately 34 million gallons of liquid material (oil and other substances) were discharged in and around U.S. waters from various marine and non-marine sources. Figure IV-2 shows the general area of these polluting incidents. Approximately 66% of the polluting incidents and 49% of the total volume spilled in 1976 occurred on the Atlantic and Gulf Coasts combined, which is expected because

Figure IV–1 LOCATION OF MAJOR REFINERIES AND TANKER TERMINALS ACCESSIBLE FROM THE COAST

SOURCE: Modified and Adapted from: International Petroleum Encyclopedia, 1976

Cruda Oil Pipaline Map of the United States and Canada, Oil and Gas Journal, 1978.



NOTE: INCLUDES CRUDE OIL, GASOLINE, FUEL OIL, DIESEL OIL, ASPHALT, WASTE OIL SOLVENT, VEGETABLE OIL, LIQUID CHEMICALS, AND OTHER POLLUTANTS (INCLUDING SEWAGE, DREDGE SPOILS, ETC.)

Figure IV–2 GENERAL AREAS OF POLLUTION

SOURCE: Adapted from: Polluting Incidents in and Around U.S. Waters, Calendar Year 1976, Pollution Incident Reporting System, U.S. Coast Guard, Washington, D.C.

both of these Coasts handle the majority of tanker traffic. Tables IV-1 and IV-2, give the specific locations and sources of these 1976 discharges. Approximately 95.6% of the polluting incidents and 75.7% of the total volume spilled occurred within 12 miles of the U.S. Coast (inland waters included). Of the 34 million gallons spilled, tankers contributed approximately 9 million gallons (26%) and tank barges contributed 2 million gallons (6%). These two sources account for approximately 11 million gallons or 32% of the total liquid material discharged into U.S. waters. Table IV-3 provides a breadkown of the various causes of pollutant incidents. By volume, the structural failure category contributed the greatest amount of pollution in 1976.

While it is difficult to determine exactly what percentage of this pollution was the result of vessels receiving Title XI government aid engaged in the domestic trade, it is believed that these vessels contributed a very small percentage of the total pollution entering U. S. waters.

B OIL POLLUTION (2)

1. GENERAL

A vast amount of material has been written on oil pollution and its environmental impacts during the past five years. Uncertainty is a general feature of most of the reports. Published estimates of the total annual influx of oil into the oceans of the earth vary from 1.64 million tons to 10 million tons. Table IV-4 indicates that the best estimate of the amount of petroleum hydrocarbons introduced into the world's oceans is 6.113 million metric tons annually. As indicated in Table IV-4 transportation sources contribute approximately 35 percent of this input.

In contrast, actual oil input into U.S. waters is very small in comparison to global input estimates. The average annual spillage for tankers and barges in the U.S. for the years 1973 through 1977 is illustrated in Table IV-5. This table indicates the relative location, vessel type and general cause of the spills over the last five year period. The proportion of domestic commerce versus foreign commerce was not taken into

Table IV–1
TYPE OF LOCATION OF POLLUTION
(OIL AND OTHER SUBSTANCES)

AREAS	OPEN INTERNAL WATERS	RIVERS CHANNELS	PORTS AND HARBORS	BEACHES NON-NAVIGABLE WATERS	TERRITORIAL ZONE (Shore to 3 miles)	CONTIGUOUS ZONE (3-12 miles)	HIGH SEAS (12 miles or more)	TOTALS
INLAND AREA								
NUMBER*	70	810	456	1,000	----	----	----	2,336
%	0.6	6.4	3.6	7.9	----	----	----	18.5
VOLUME	99,257	3,499,819	47,841	3,489,043	----	----	----	7,135,960
%	0.3	10.3	0.1	10.3	----	----	----	21.1
ATLANTIC								
NUMBER	----	614	1,532	155	228	52	46	2,627
%	0.0	4.9	12.1	1.2	1.8	0.4	0.4	20.8
VOLUME	----	202,756	679,182	194,286	279,123	2,437	7,522,235	8,876,019
%	0.0	0.6	2.0	0.6	1.0	0.0	22.0	26.2
PACIFIC								
NUMBER	----	203	1,480	164	345	28	17	2,237
%	0.0	1.6	11.7	1.3	2.8	0.2	0.1	17.7
VOLUME		46,946	1,089,765	83,013	218,014	1,164	4,259	1,443,161
%	0.0	0.1	3.2	0.2	0.7	0.0	0.0	4.3
GULF								
NUMBER	----	692	1,383	194	1,352	368	493	4,482
%	0.0	5.5	10.9	1.5	11.0	3.0	3.5	35.4
VOLUME	----	643,815	360,285	5,641,932	274,184	11,197	708,210	7,639,623
%	0.0	1.9	1.1	16.7	0.8	0.0	2.1	22.6
GREAT LAKES								
NUMBER	85	488	142	258	----	----	----	973
%	0.7	3.9	1.1	2.0	----	----	----	7.7
VOLUME	15,014	6,382,696	2,114,632	244,725	----	----	----	8,757,067
%	0.0	18.9	6.2	0.7	----	----	----	25.9
TOTAL								
NUMBER	155	2,807	4,993	1,771	1,925	448	556	12,655
%	1.2	22.2	39.5	14.0	15.2	3.5	4.4	100.0
VOLUME	114,271	10,776,032	4,291,705	9,652,999	767,321	14,798	8,234,704	33,851,830
%	0.3	31.8	12.7	28.5	2.2	0.1	24.3	100.0

* NUMBER OF INCIDENTS

SOURCE: Adapted from: Polluting Incidents in and around U.S. Waters, Calendar Year 1976, Pollution Incident Reporting System, U.S. Coast Guard, Washington, D.C.

Table IV–2
SOURCES OF POLLUTION
(OIL AND OTHER SUBSTANCES)

SOURCE	NUMBER OF INCIDENTS	% OF TOTAL	VOLUME IN GALLONS	% OF TOTAL
VESSELS				
1. DRY CARGO SHIPS	41	0.3	11,679	0.0
2. DRY CARGO BARGES	324	2.6	24,840	0.1
3. TANK SHIPS	623	4.9	8,930,029	26.4
4. TANK BARGES	976	7.7	1,953,442	5.8
5. COMBATANT VESSELS	179	1.4	26,987	0.1
6. OTHER VESSELS	1,153	9.1	245,013	0.7
TOTAL	3,296	26.0	11,191,990	33.1
LAND VEHICLES				
1. RAIL VEHICLES	82	0.6	269,440	0.8
2. HIGHWAY VEHICLES	335	2.6	323,391	1.0
3. OTHER/UNKNOWN VEHICLES	47	0.4	20,968	0.1
TOTAL	464	3.6	613,799	1.9
NON–TRANSPORTATION–RELATED FACILITIES				
1. ONSHORE REFINERY	101	0.8	211,614	0.6
2. ONSHORE BULK/STORAGE	365	2.9	5,873,932	17.4
3. ONSHORE PRODUCTION	242	1.9	349,053	1.0
4. OFFSHORE PRODUCTION FACILITIES	1,358	10.7	274,732	0.8
5. OTHER FACILITIES	1,055	8.3	9,749,869	28.8
TOTAL	3,121	24.6	16,469,200	48.0
PIPELINES	653	5.2	4,530,094	13.4
MARINE FACILITIES				
1. ONSHORE/OFFSHORE BULK CARGO TRANSFER	321	2.5	333,712	1.0
2. ONSHORE/OFFSHORE FUELING	88	0.7	21,708	0.1
3. ONSHORE/OFFSHORE NONBULK CARGO TRANSFER	23	0.2	15,643	0.0
4. OTHER TRANSPORTATION–RELATED MARINE FACILITY	128	1.0	5,787	0.0
TOTAL	560	4.4	376,850	1.1
LAND FACILITIES	182	1.4	442,730	1.3
MISC/UNKNOWN	4,379	34.6	227,167	0.7
TOTAL	12,655	100.0	33,851,830	100.0

SOURCE: Polluting Incidents in and around U.S. Waters, Calendar Year 1976, CG 487, Pollution Incident Reporting System, U.S. Coast Guard, Washington, D.C.

Table IV–3
CAUSES OF POLLUTION
(OIL AND HAZARDOUS SUBSTANCES)

INCIDENT	NUMBER OF INCIDENTS	% OF TOTAL	VOLUME IN GALLONS	% OF TOTAL
MATERIAL/DESIGN EQUIPMENT FAILURE				
HULL/TANK RUPTURE/LEAK	782	6.2	8,128,139	24.0
TRANSPORTATION PIPELINE RUPTURE/LEAK	522	4.1	2,281,746	6.7
OTHER STRUCTURAL FAILURE	411	3.2	12,193,880	36.0
PIPE RUPTURE/LEAK	875	6.9	4,120,886	12.2
RAILROAD/HIGHWAY/AIRCRAFT ACCIDENTS	257	2.0	481,647	1.4
VALVE FAILURE	400	3.2	277,387	0.8
PUMP FAILURE	158	1.2	648,773	1.9
OTHER RUPTURE/LEAK	343	2.7	80,343	0.2
OTHER EQUIPMENT FAILURE	1,025	8.1	905,502	2.7
HUMAN ERROR				
TANK OVERFLOW	1,072	8.5	273,272	0.8
IMPROPER HANDLING OPERATION	499	3.9	346,449	1.0
OTHER PERSONNEL ERROR	530	4.2	434,786	1.3
BILGE PUMPING	242	1.9	9,407	0.0
BALLAST PUMPING	34	0.3	2,085	0.0
OTHER INTENTIONAL DISCHARGE	228	1.8	784,378	2.3
NATURAL OR CHRONIC PHENOMENON	318	2.5	118,798	0.4
UNKNOWN	4,959	39.2	2,764,352	8.2
TOTAL	12,655	100.0	33,851,830	100.0

SOURCE: Polluting Incidents in and Around U.S. Waters, Calendar Year 1976, CG–487, Pollution Incident Reporting System, U.S. Coast Guard, Washington, D.C.

Table IV–4
BUDGET OF WORLDWIDE PETROLEUM HYDROCARBONS INTRODUCED INTO THE OCEANS

SOURCE	INPUT RATE (MTA)[a]	
	BEST ESTIMATE	PROBABLE RANGE
OFFSHORE PRODUCTION	0.08	0.08–0.15
TRANSPORTATION		
LOT[b]	0.31	0.15–0.4
NON–LOT TANKERS	0.77	0.65–1.0
DRY–DOCKING	0.25	0.2–0.3
TERMINAL OPERATIONS	0.003	0.0015–0.005
BILGES, BUNKERING[d]	0.5	0.4–0.7
TANKER ACCIDENTS	0.2	0.12–0.25
NONTANKER ACCIDENTS	0.1	0.02–0.15
COASTAL REFINERIES	0.2	0.2–0.3
ATMOSPHERIC RAINOUT[c]	0.6	0.4–0.8
COASTAL MUNICIPAL WASTES	0.3	–
COASTAL, NONREFINING, INDUSTRIAL WASTES	0.3	–
URBAN RUNOFF	0.3	0.1–0.5
RIVER RUNOFF	1.6	–
SUBTOTAL	5.513	
NATURAL SEEPS	0.6	0.2–1.0
TOTAL	6.113	

a MTA, MILLION METRIC TONS ANNUALLY.

b LOT IS AN ABBREVIATION FOR "LOAD–ON–TOP"

c BASED UPON ASSUMED 10 PERCENT RETURN FROM THE ATMOSPHERE

d FOR ALL SHIPS EQUIVALENT TO AN AVERAGE LOSS PER SHIP OF ABOUT 10 TONS PER ANNUM

e 1 METRIC TON = 311 GALLONS (ASSUMING A SPECIFIC GRAVITY OF 0.85 FOR OIL)

SOURCE: National Academy of Sciences Report, Petroleum in the Marine Environment, Washington, D.C., 1975, page 6.

Table IV–5

REPORTED VESSEL SPILLAGES OF SIZES GREATER THAN 50,000 GALLONS APRIL 1973 THROUGH MARCH 1977

AVERAGE ANNUAL VESSEL SPILLAGE = 8,320,000 BARRELS SPILLED PER YEAR					
SPILL LOCATIONS	% BY VOLUME	VESSEL TYPE	% BY VOLUME	SPILL CAUSES	% BY VOLUME
INLAND WATERWAYS	27	TANKER	59.5	GROUNDING	35.3
GREAT LAKES	21	BARGE	34.0	COLLISION	38.0
PACIFIC COAST	7	OTHER VESSEL	6.5	OTHER	26.7
GULF COAST	10				
ATLANTIC COAST	35				

SOURCE: Adapted from Major Spills from Tankers and Barges and other Vessels in U.S. Waters, Analysis of Recent Trends and Patterns, Report to CEQ, Young, GK, Warner, L.S., Tettmar, R.Y., May 1977.

consideration in this study. Outflows in U.S. Waters for calendar year 1976 (the latest year for which such data are available) reported to the U.S. Coast Guard are shown in Table IV-6 (3). The total oil outflow volume is over 23 million gallons which amounts to approximately 0.074 million metric tons of oil (assuming a specific gravity of 0.85 for oil). However, the data in Table IV-6 indicate vessel sources contributed approximately 46 percent of the total input to U.S. waters during calendar year 1976.

A compilation of oil outflow data from tankships and tankbarges for a variety of causes is shown in Table IV-7. It should be noted that the total number of oil pollution incidents that occurred to tank barges during calendar year 1976 is about 1-1/2 times larger than the total number that occurred to tankships, but the volume of oil outflow from tank barge incidents is less than one-sixth the amount from tankships. (3).

2. TANKERS

Accurate estimates of oil spillage from tankers are difficult to obtain. The estimates of tanker related oil pollution varies widely depending on the choice of assumptions or factors and the available information concerning tankers. Figure IV-3 shows a breakdown of the tanker oil pollution problem (4,5). Examples of these factors include: amount of oil retained on board after discharge of cargo ("clingage") number of tanks washed, oil content of water discharged, amount of oil leaked to bilges, quantities of dirty lube oil and purifier sludge produced, cargo handling spills and spills as a result of tanker accidents. Table IV-8 and Figure IV-4 provide an estimate of the amount of oil pollution from various tank vessel sources. Actual spillage data for U.S. waters is given in Table IV-6. Oil pollution from tankers originates from two principal sources: (1) normal tanker operations, such as tank cleaning, ballasting and other operational reasons for periodically discharging oil overboard and (2) various types of tanker accidents.

a. OPERATIONAL POLLUTION

Tank cleaning and ballasting accounts for approximately one million

Table IV–6
SOURCES OF OIL POLLUTION IN U.S. WATERS

SOURCE	NUMBER OF INCIDENTS	% OF TOTAL	VOLUME IN GALLONS	% OF TOTAL
VESSELS				
1. DRY CARGO SHIPS	38	0.4	11,513	0.0
2. DRY CARGO BARGES	303	2.8	22,718	0.1
3. TANK SHIPS	577	5.4	8,924,675	38.6
4. TANK BARGES	909	8.5	1,370,909	5.9
5. COMBATANT VESSELS	179	1.7	26,987	0.1
6. OTHER VESSELS	1,099	10.3	243,605	1.1
TOTAL	3,015	29.1	10,699,407	45.8
LAND VEHICLES				
1. RAIL VEHICLES	60	0.6	167,220	0.7
2. HIGHWAY VEHICLES	310	2.9	297,968	1.3
3. OTHER/UNKNOWN VEHICLES	43	0.4	7,848	0.0
TOTAL	413	3.9	473,036	2.0
NON–TRANSPORTATION RELATED FACILITIES				
1. ONSHORE REFINERY	88	0.8	11,296	0.0
2. ONSHORE BULK/STORAGE	337	3.2	5,817,212	25.2
3. ONSHORE PRODUCTION	234	2.2	348,457	1.5
4. OFFSHORE PRODUCTION FACILITIES	1,312	12.3	274,318	1.2
5. OTHER FACILITIES	892	8.4	374,792	1.6
TOTAL	2,863	26.9	6,826,075	29.5
PIPELINES	627	5.9	4,362,421	18.9
MARINE FACILITIES				
1. ONSHORE/OFFSHORE BULK CARGO TRANSFER	286	2.7	274,677	1.2
2. ONSHORE/OFFSHORE FUELING	86	0.8	21,708	0.1
3. ONSHORE/OFFSHORE NONBULK CARGO TRANSFER	21	0.2	15,583	0.1
4. OTHER TRANSPORTATION–RELATED MARINE FACILITY	118	1.1	4,599	0.0
TOTAL	511	4.8	316,567	1.4
LAND FACILITIES	166	1.6	355,233	1.5
MISC/UNKNOWN	2,975	27.9	191,975	0.8
TOTAL	10,660	100.0	23,125,714	100.0

SOURCE: Polluting Incidents In and Around U.S. Waters, Calendar Year 1976, CG–487, Pollution Incident Reporting System, U.S. Coast Guard, Washington, D.C.

Table IV–7
OIL POLLUTION INCIDENTS OF TANK SHIPS AND TANK BARGES IN AND AROUND U.S. WATERS

CAUSE	TANK SHIPS		TANK BARGES	
	NUMBER OF INCIDENTS	VOLUME IN GALLONS	NUMBER OF INCIDENTS	VOLUME IN GALLONS
HULL OR TANK LEAK	68	1,321,216	276	1,137,965
TRANSPORTATION PIPE RUPTURE OR LEAK	5	375	9	92,963
OTHER STRUCTURAL FAILURE	5	7,502,257	16	600
PIPE RUPTURE OR LEAK	14	1,170	18	305
OTHER RUPTURE OR LEAK	20	9,923	35	3,744
VALVE FAILURE	57	5,082	53	6,798
PUMP FAILURE	3	192	19	3,988
OTHER EQUIPMENT FAILURE	39	1,693	108	4,501
TANK OVERFLOW	154	41,690	215	21,953
IMPROPER EQUIPMENT OPERATION/HANDLING	46	14,869	69	8,053
OTHER PERSONNEL ERROR	38	4,727	45	87,329
RAILROAD, HIGHWAY, AIRCRAFT ACCIDENT	2	201	–	–
BILGE PUMPING	28	4,251	4	425
BALLAST PUMPING	13	1,076	1	0
OTHER INTENTIAL DISCHARGE	14	1,847	4	17
NATURAL OR CHRONIC PHENOMENON	6	511	2	2
UNKNOWN	65	13,595	35	2,226
TOTAL	577	8,924,675	909	1,370,909

SOURCE: Polluting Incidents In and Around U.S. Waters, Calendar Year 1976, C6-487, Pollution Incident Reporting System, U.S. Coast Guard, Washington, D.C.

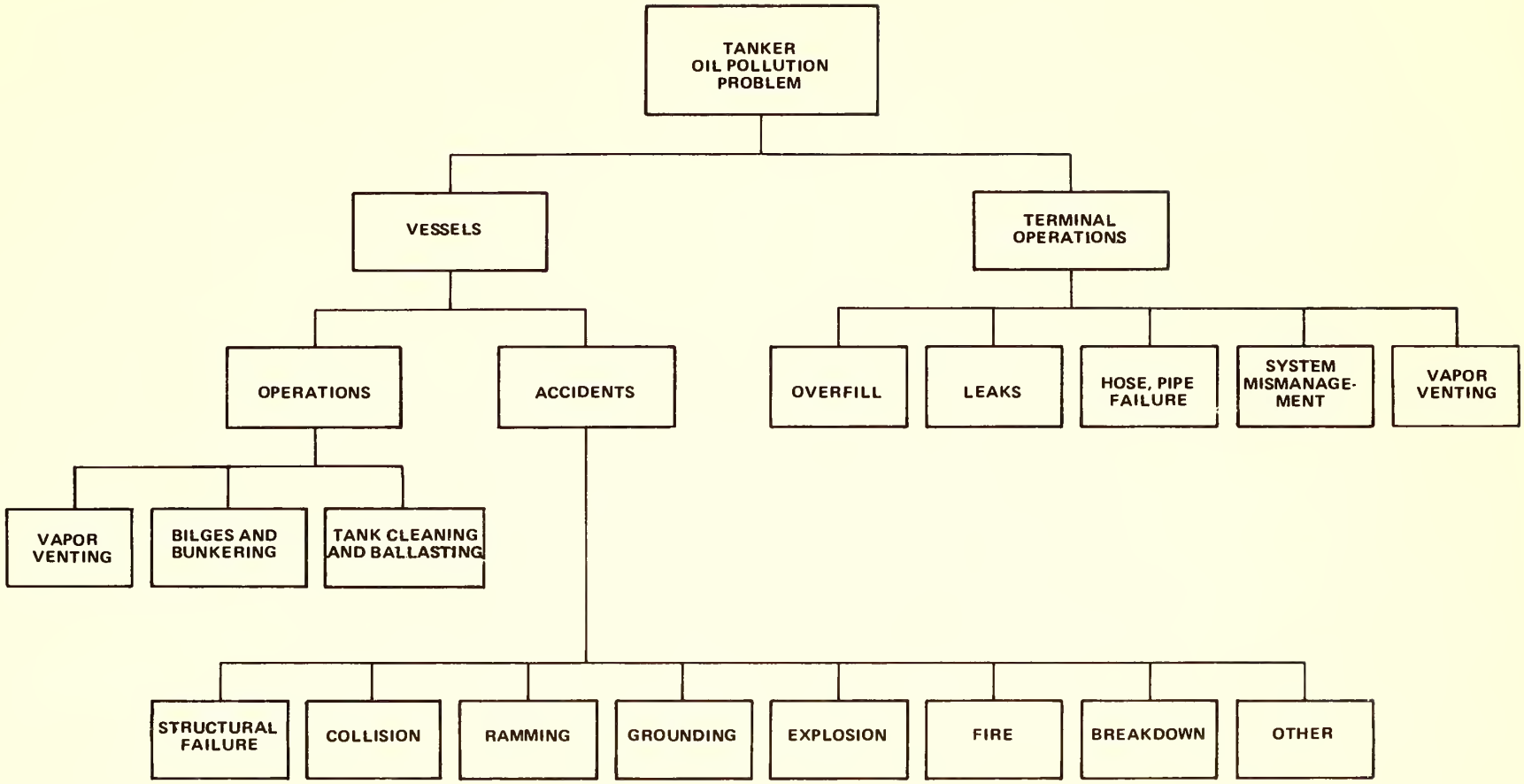


Figure IV–3 THE TANKER OIL POLLUTION PROBLEM

SOURCE: Adapted from: Porricelli, Keith and Storch, "Tankers and the Ecology," Transactions of the Society of Naval Architects and Marine Engineers, 1971

Table IV–8
ESTIMATED ANNUAL OIL INPUTS TO THE OCEAN FROM TANKERS

SOURCE	ESTIMATED OIL INPUTS (THOUSANDS OF METRIC TONS PER YEAR) [2]				
	WORLDWIDE	U.S. VESSELS		U.S. WATERS	
		FOREIGN TRADE	DOMESTIC TRADE		
TANK CLEANING AND BALLASTING					
– BALLASTING AND DEBALLASTING OPERATIONS INCLUDING ASSOCIATED TANK WASHING, CRUDE OIL (Note 1)	426	3	24	29	
– TANK CLEANING FOR REMOVAL OF SLUDGE BUILDUP, CRUDE OIL (Note 1)	259	1.8	16	19	
– TANK CLEANING OF REFINED PRODUCT TANKERS FOR BALLAST AND TO INSURE PURITY OF NEXT CARGO	162	0.5	43	44	
– TANK CLEANING PRIOR TO SHIPYARD REPAIRS	240	1.8	7.2	9	
SUBTOTAL FOR TANK CLEANING AND BALLASTING	1,087	7.1	90.2	101	
TANKER BILGES AND BUNKERING	60	0.6	2.3	3	
TERMINAL OPERATIONS	3	0.02	0.4	0.6	
				U.S. SHIPS	FOREIGN SHIPS
TANKER ACCIDENTS					
– BREAKDOWNS	6				
– COLLISIONS	40		1	1	0.5
– EXPLOSIONS	20		0.4	0.4	
– FIRES	1				
– GROUNDINGS	50	0.6	0.8	0.8	2.4
– RAMMINGS	3		0.3	0.3	0.5
– STRUCTURAL FAILURES	70		6[2]		1.2
– OTHER (INCLUDING FLOODING OF MACHINERY SPACE)	10				
SUBTOTAL FOR TANKER ACCIDENTS	200	0.6	8.5	2.5	4.6
TOTAL OIL INPUTS FROM TANKERS	1,350	8.3	101.4	111.7	

Notes on following page.

Table IV–8 (Cont'd.)

NOTES:
1. FOR U.S. VESSELS AND U.S. WATERS, FIGURES SHOWN INCLUDE THOSE FROM BOTH CRUDE OIL AND RESIDUAL OIL. CRUDE AND RESIDUAL OILS HAVE BEEN TREATED TOGETHER BECAUSE PRESENTLY AVAILABLE LOT METHODS WORK FOR BOTH.
2. TOTAL LOSS OF A 29,950 DEADWEIGHT TON VESSEL IS INCLUDED.
3. ESTIMATES FOR OPERATIONAL POLLUTION INPUTS ARE DESCRIBED IN APPENDIX 2 OF REFERENCE 2.
4. ESTIMATES FOR TANKER ACCIDENTS ARE BASED ON PERIOD 1969–1973 WITH DATA COLLECTED FROM LLOYDS WEEKLY CASUALTY REPORTS, CG POLLUTION AND VESSEL CASUALTY REPORTS.

SOURCE: Final Environmental Impact Statement, Regulations for Tank Vessels Engaged in the Carriage of Oil in Domestic Trade, 1975, U.S. Coast Guard.

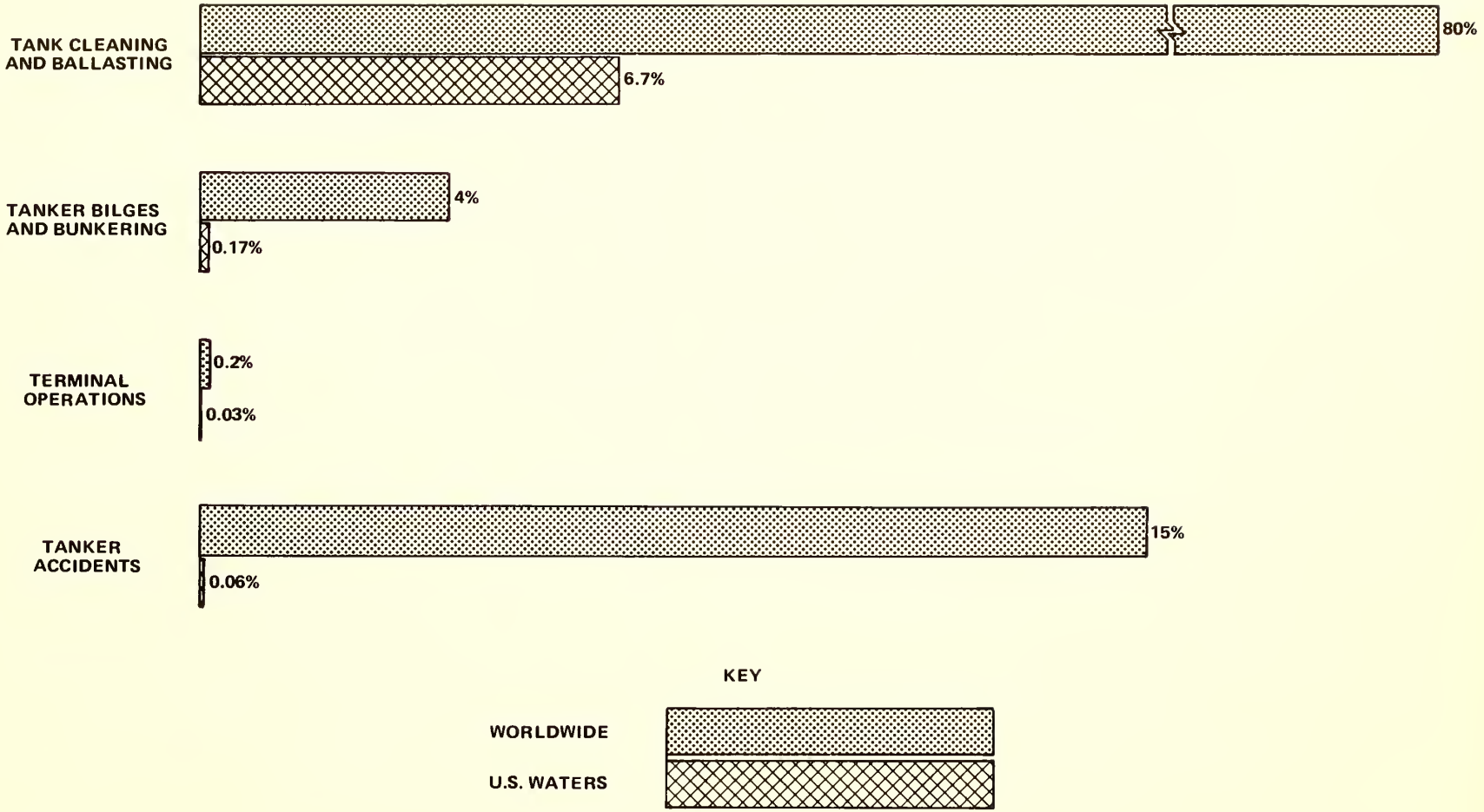


Figure IV–4 SOURCES OF THE ESTIMATED 1.35 MILLION TONS OF OIL ENTERING THE OCEANS EACH YEAR FROM TANKERS

SOURCE: Based on data presented in Table IV–8.

metric tons of the estimated six million tons of oil entering the marine environment from all sources each year. (Bilges contribute another 200,000). As indicated in Figure IV-4, oil from tank cleaning and ballasting accounts for approximately 80 percent of the oil tanker spillage, with the remainder from tanker bilges, bunkering, cargo handling spills, and tanker accidents. Tanker bilge discharges are the required periodic pumpage from the ship's bilge which has become fouled by oil from cargo and machinery spaces. Bunkering operational spills are those which occur during vessel refueling operations. These discharges would be very similar to those made during cargo handling operations. The amount of oil spilled as a result of cargo handling depends on the number of cargo transfers and the measures taken to avoid such spills.

There are three principal causes of terminal spills. These are: (1) mechanical faults; (2) design faults; and (3) human error. Based on the existing reporting system to the U.S. Coast Guard, human error is the predominant cause and is the most difficult to remedy. Mechanical failures include: (1) cargo hose bursts; (2) piping, fitting, or flange failures either ashore, or on the tanker; and (3) tank ruptures. Any of the foregoing items could have also been an inherent design fault. Design faults also include the incompatibility of the tanker's cargo transfer equipment with a given terminal.

A spill may result from overfill of a cargo tank of a tanker. The overfill of a cargo tank may be prevented by employing a closed gauging system, but in some cases the system fails as a result of human error or negligence.

b. TANKER ACCIDENTS

Vessel accidents are estimated to contribute about 15 percent of the oil entering the marine environment from tankers. The estimated annual oil spills from accidents is shown in Tables IV-5 and IV-7 and illustrated in Figure IV-4.

A recent analysis (February 1978) of 3,709 worldwide tanker accidents which occurred between January 1, 1969 and December 31, 1974 was

prepared by the Office of Technology Assessment (OTA) Oceans Program (5). The analysis considered tankers of gross registered tonnage equal to or greater than 2000 tons. The accident types include mechanical breakdowns, collisions, explosions, fires, groundings, rammings, structural failures and all others. The distribution among accident types including those leading to Pollution-Causing Incidents (PCI's) and the total oil pollution outflow is given in Table IV-9. The OTA found that groundings and collisions together accounted for nearly 50% of the total accidents over this six year sampling period. Approximately 14 percent of the tanker accidents resulted in a pollution causing incident.

An analysis was also conducted of accidents occurring within the Coastal Zones Contiguous to the Atlantic, Gulf, and Pacific Coasts of North America. Table IV-10 shows the number of total accidents, the number of Pollution-Causing-Incidents (PCI's) and the amount of total outflow for each of the three coasts. Approximately 14 percent of the accidents, PCI's, and total outflow for the three coasts combined occurred within 50 nautical miles of land (exclusive of an entranceway, harbor or at a pier).

A notable major tanker accident that occurred in U.S. waters was the collision between the OREGON STANDARD and ARIZONA STANDARD. These two tankers collided on January 18, 1971 dumping 20,000 barrels of Bunker C fuel oil into the marine environment. The oil was carried by tidal currents to beaches both above and below the entrance to San Francisco Bay. Because tanker accidents often occur in a dramatic way, accidental pollution has received more attention and public comment than any other source of pollution.

The United States,in preparation for the 1973 IMCO Marine Pollution Conference,prepared a study entitled "An Analysis of Oil Outflow Due to Tanker Accidents." (6) The authors concluded the following:

- Every tanker, on the average, is likely to be involved in an accident once every nine years during its lifetime.
- Approximately one out of every six of these casualties (133 per year) is likely to result in a polluting incident; or one out of

Table IV–9
WORLDWIDE TANKER ACCIDENTS AND OIL POLLUTION OUTFLOW

TYPE OF ACCIDENT	NUMBER OF EVENTS	NUMBER OF PCI's	TOTAL OUTFLOW (LONG TONS)
BREAKDOWNS	403	12	48,763
COLLISIONS	877	147	226,884
EXPLOSIONS	127	40	134,610
FIRES	233	17	2,935
GROUNDINGS	935	144	309,824
RAMMINGS	543	51	14,506
STRUCTURAL	586	104	340,727
ALL OTHERS	5	4	54,911
TOTAL	3,709	519	1,133,160

NOTES:
1. Involves Tankers 2000 Gross Registered Tonnage (GRT) and greater during the period 1969 to 1974
2. Catastrophic Events are included
3. PCI = Pollution Causing Incident

SOURCE: "An Analysis of Oil Tanker Casualties, 1969–1974", prepared by OTA Oceans Program for the Use of the U.S. Senate Committee on Commerce, Science and Transportation, Washington, D.C., February 7, 1978.

Table IV–10
DISTRIBUTION OF TANKER ACCIDENTS, PCI'S, AND OUTFLOW AMONG THREE COASTS OF NORTH AMERICA DURING 1969 TO 1974 PERIOD AS A WHOLE AND ONLY THOSE WITHIN COASTAL ZONES

GEOGRAPHIC LOCATION	TOTAL ACCIDENTS	ACCIDENTS WITHIN 50 NMI OF LAND BUT NOT WITHIN ENTRANCEWAY, HARBOR, OR AT PIER	PCI's 3. TOTAL	PCI'S WITHIN 50 NMI OF LAND BUT NOT WITHIN ENTRANCEWAY, HARBOR, OR AT PIER	TOTAL OUTFLOW	OUTFLOW WITHIN 50 NMI OF LAND BUT NOT WITHIN ENTRANCEWAY, HARBOR, OR AT PIER
EAST COAST OF NORTH AMERICA	430	62	70	13	195,042[1.]	22,677[2.]
GULF OF MEXICO/ CARIBBEAN SEA	283	32	30	2	14,889	6,195
WEST COAST OF NORTH AMERICA	78	14	13	1	9,228	1,350
TOTAL	791	108	113	16	219,159	30,222

1. Includes 4 catastrophic structural failures which occurred at sea with total outflow of 110,360 long tons and 1 explosion which also occurred at sea with total outflow of 31,716 long tons.
2. Includes 2 catastrophic structural failures with total outflow of 17,878 long tons.
3. PCI = Pollution Causing Incident
4. NMI = Nautical Mile

SOURCE: "An Analysis of Oil Tanker Casualties 1969 – 1973", prepared by OTA Oceans Program for the Use of the U.S. Senate Committee on Commerce, Science and Transportation, Washington, D.C., February 7, 1978

three tankers is likely to be involved in a polluting accident dur-its 20 year life.

. The average annual outflow from all tanker casualties is approximately 218,000 metric tons.

. Approximately 12 percent of the polluting incidents account for three quarters of the total outflow. This 12 percent is comprised of structural failures, groundings, and explosions involving the total loss of the tanker. An important conclusion to draw from here is that incidents involving the total loss of the tanker have a distinct effect upon the analysis;

. The single largest type of tanker casualty in causing pollution is structural failure. Ten structural failures involving tankers with an average age of 17 years and an average size of 27,443 DWT, resulted in the total loss of the vessel and 48 percent of the total outflow in 1969 and 1970;

. The next largest type of tanker casualty in causing pollution is groundings. Outflows from groundings exceed those from collisions by a factor of 4.25. This is with an equal frequency of occurrence of either type of casualty. Groundings accounted for 29 percent of the total outflow in 1969 and 1970;

. There is no clear indication that there is any relationship among tanker size, casualty frequency and oil outflow magnitude other than in the case of explosions on very large tankers;

. Certain flags of registry appear to need higher levels of standards and maintenance;

. Analysis of tanker pollution data by counting numbers of incidents only, without resource to the amount of outflow, can be misleading.

Recently the U.S. Coast Guard issued proposed regulations defining the distribution of segregated ballast in tankers of over 20,000 DWT.

These regulations are based on the following: (7)

. Tank vessel accidents are statistically small in number involving random unpredictable events. The number of accidents that result in spillage is even smaller, on the order of one-fourth of the accident events. Further, accident analysis shows that about 80 percent of the oil pollution outflow is caused by approximately 2 percent of the accidents.

. The historical data with respect to the relative frequencies of occurrences of side damaging accidents as a result of groundings reveal that the side damaging accidents occur 1.5 times as often as the bottom damaging accidents.

Data on spill frequency by type of accident are considered more reliable because of better reporting procedures. These data reveal that spills from the side of a vessel from collisions and rammings occur 1.4 times as often as the spills from the bottom area. These two factors would suggest a preference for side protection over bottom protection. The Coast Guard studied a large number of U.S. Salvage Association damage reports to determine if there were any particular areas of the tanker's cargo tank that were more prone to damage. The study revealed that no particular area of the tanker is immune to damage; however, the area of the turn of the bilge was identified as one damage prone area.

3. TANK BARGES

It was indicated in Section IV-B1 that the sources of oil pollution from tank barges are the result of (1) discharges due to leaks, (2) spills during loading and unloading of cargo at terminals and (3) barge accidents. The reason for discharges as a result of leaks and spills during loading and unloading are similar to those for tankers and will not be discussed in this section.

a. TANK BARGE ACCIDENTS (8, 9)

The U.S. Coast Guard performed an analysis of tank barge casualties that occurred during fiscal year 1971), for the Council on Environmental

Quality Deep Water Port Study. There were 497 reports on file for tank barge casualties throughout United States waters (East and West Coasts, Great Lakes, Western Rivers, Gulf and intercoastal waterways). Pollution was indicated for 49 of the 497 tank barge casualties. Twenty of these 49 cases were analyzed because of their significant impact; i.e., cases in which pollution occurred at the loading dock were not included in the analysis. Tank barge casualty statistics involving only petroleum products were included in this analysis.

Table IV-11 is a distribution of the 20 tank barge polluting incidents by type of casualty, causes and oil outflow magnitude. The parameters of barge length and tonnage did not appear to have any influence on pollution potential.

The above statistics cannot be used to determine trends because the causes of the casualties considered are the most probable, and therefore are only speculative. In almost every case, however, the casualties may have been avoided had the vessel operators been alert for the situation encountered.

Conclusions were not made regarding the effect of tow length on pollution, however, in a few of the tows, the towboat horsepower was insufficient to control the tow in a strong current. While it was not directly concluded from the data, it was assumed that the controllability of a tow is dependent upon the towboat horsepower and the currents in the channel.

Since oil was not carried in the bow or stern compartments of the barges, those locations were not specifically noted as damage locations. Where side damage was indicated for grounding casualties, it was at the bilge corner of the barge, and could possibly have been prevented by effective double side construction. The one collision case that showed bottom damage was caused from the vessel grounding. In all the collision cases, side damage was not extensive enough to cause pollution if double sided construction been employed. Double bottoms would have probably prevented oil spillage in all cases where bottom damage occurred.

Table IV–11
ANALYSIS OF 20 TANK BARGE CASUALTIES

TYPE OF CASUALTY	NO. OF CASUALTIES	AMOUNT OF OIL SPILLED (TONS)	% OF TOTAL OIL SPILLED
GROUNDINGS	10	1,142	78.24
COLLISION (VESSEL STRUCK BY ANOTHER VESSEL)	6	233	16.00
COLLISION (WITH BARGE)	2	72	4.89
COLLISION (WITH TOW)	2	13	0.87
SUB–TOTAL	20	1,260	100.00

CAUSE FACTOR	NUMBER OF CASUALTIES
PILOT ERROR	9
WEATHER	4
BARGE OVERLOADED	5
LACK OF COMMUNICATION	2
WATER CURRENT	4
EXCESS BARGE SPEED	2
TOO CLOSE TO BANK	3
INADEQUATE TOWBOAT HORSEPOWER	2
OTHER	6
TOTAL	37*

* OF THE 20 INCIDENTS, SOME HAD A MULTIPLICITY OF CASUALTY FACTORS.

SOURCE: Tank Barge Study, Joint Maritime Administration/ U.S. Coast Guard, October 1974

Unpublished Material Developed for Council on Environmental Quality Study on Deep Water Ports, 1972.

4. FATE OF OIL SPILLS (10, 11)

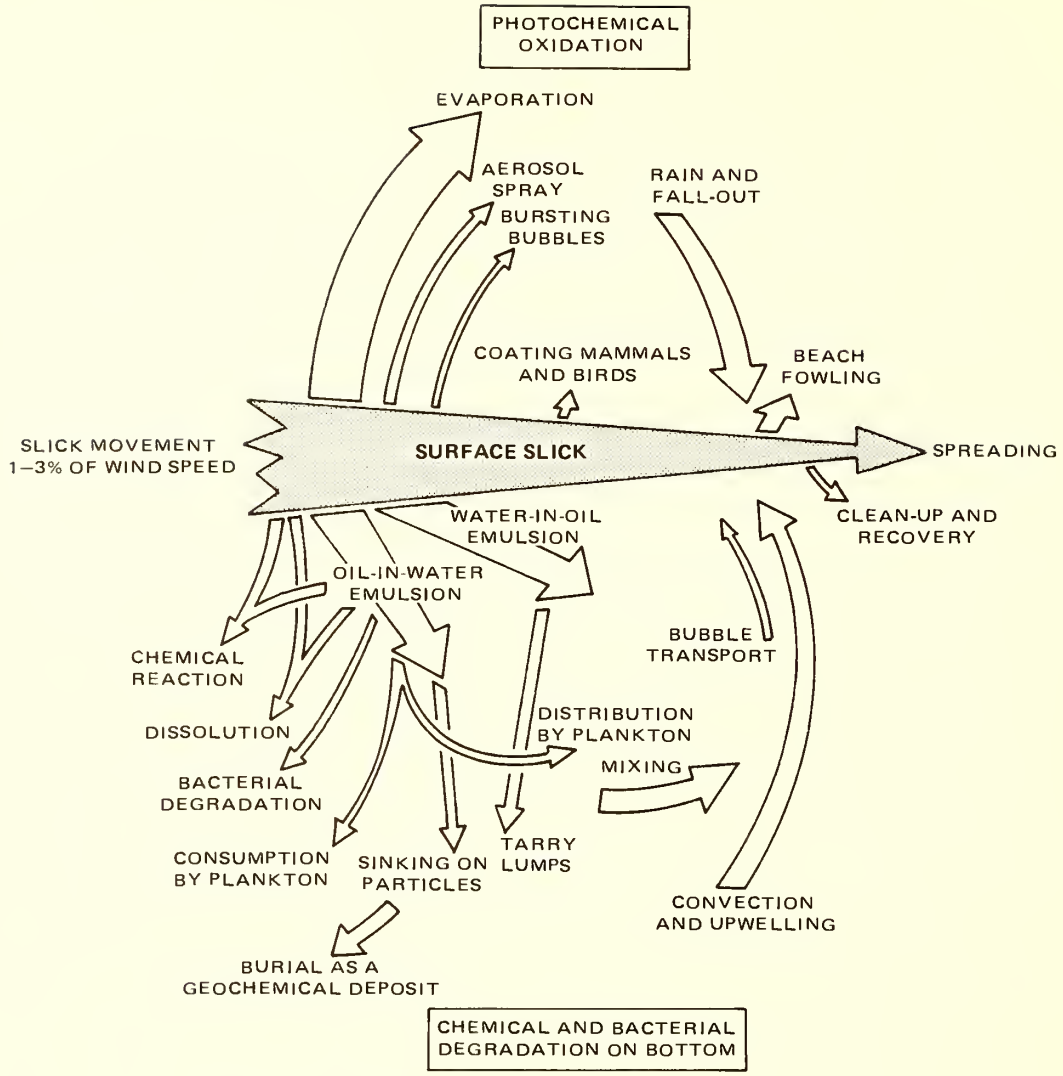
a. GENERAL BEHAVIOR OF PETROLEUM PRODUCTS IN THE MARINE AND AQUATIC ENVIRONMENT

The impacts to the marine and aquatic environments created by bulk liquid spillage by waterborne commerce may be categorized as those attributed to: (1) routine, long term release of oil into the world's oceans, (2) fairly frequent, but low level introduction of oil into a specific locality such as around fresh and marine water oil terminals and harbors, (3) relatively infrequent catastrophic large spills concentrated in a relatively small geographic area. These risks are not all the same. The environmental impacts would vary depending upon spill size, frequency and locality of oil input, oil type, waterway and oceanographic conditions, meteorological conditions, turbidity, season, biota and method of spill clean-up. The complex interactions of these variables are illustrated in Figure IV-5.

b. PETROLEUM COMPOSITION

The hydrocarbon composition of petroleum varies greatly, depending upon where it is obtained and the type of product. Toxicity of each type of oil depends substantially on the water soluble and aromatic fractions and other hydrocarbon constituents of the petroleum.

Petroleum products are composed of alkanes (also referred to as paraffins or saturates), alkenes (olefins), and aromatics. Alkanes are chains of carbon atoms with attached hydrogen atoms and may be simple straight chains (normal), branched chains, or simple rings (napthetic). As with most classes of organic compounds, the higher the number of carbon atoms in a molecule, the higher its boiling point and the less volatile and soluble it becomes. Low boiling alkanes produce anaesthesia and narcosis at low concentrations and at high concentrations cause cell damage and death among a wide variety of lower marine and aquatic biota. Higher boiling alkanes are naturally produced by life processes and are found in all marine organisms. Higher boiling alkanes of petroleum origin are not normally toxic; however, they may affect chemical communication and in-



NOTE: ARROW SIZE DENOTES RELATIVE VOLUMES OF SPILL DYNAMICS.

Figure IV–5 PROCESSES AFFECTING OIL SPILLED AT SEA

MODIFIED AND ADAPTED FROM: A. Nelson Smith, Oil Pollution and Marine Ecology, Plenum Press, New York, 1973.

terfere with metabolic and physiological processes.

Alkenes are between alkanes and aromatics in structure and properties. They are not found in crude oils, but in some refined products, such as gasoline, and in cracking products. Alkenes are relatively more toxic than alkanes, but less so than aromatics.

Aromatic hydrocarbons are characterized by the possession of six member benzene rings. Low boiling aromatics are relatively the most toxic and mutagenic compounds found in oil. Higher boiling aromatics, especially multi-ring compounds, are suspected as long-term poisons and some are known carcinogens causing malignant growths.

Petroleum spills on water as illustrated in Figure IV-5 are degraded chemically, by evaporation, dissolution, microbial action, chemical oxidation, and photo-chemical reactions - often collectively called weathering. The speed of degradation is markedly influenced by hydrocarbon constituents, light, temperature, nutrients and inorganic substances, winds, tides, currents, and waves. They all affect the microbial degradation, evaporation, dissolution, dispersal, and sedimentation processes. Degradation rates appear to vary with the specific hydrocarbon composition of the oil. The more toxic fractions are generally less susceptible to microbial degradation, and have greater evaporation and dissolution rates. The heavy residuals that do not degrade may be deposited in sediments or they may float as tar lumps or tar balls.

c. PHYSICAL AND CHEMICAL CHANGES (WEATHERING)

Since oil and petroleum products are a complex mixture of many hydrocarbon compounds. The effects on marine organisms vary with the specific oil spilled. As stated previously, the chemical composition of spilled oil is altered significantly by evaporation, dissolution, and chemical oxidation. Because the varying constitutents of oil are affected at different rates by these "weathering" processes, the relative composition and, therefore, the biological effects of spilled oil will vary.

Evaporation depletes the more volatile components but causes little

separation (fractionation) between hydrocarbons that have the same boiling points but substantially different structures and effects on organisms. Hydrocarbons are quickly lost through evaporation and aerosolization into the atmosphere.

Dissolution preferentially removes the lower molecular weight components from an oil slick based on the hydrocarbon solubility. Some potentially toxic fractions, such as the aromatic hydrocarbons which have a higher solubility than the less toxic and insoluble compounds, such that once dissolved in seawater, these soluble constitutents follow quite different pathways than the more conspicuous slick.

Biochemical (microbial) attack affects compounds within a much wider boiling range than evaporation and dissolution. Hydrocarbons with the same general chemical structures are attacked at about the same rates. Normally, paraffins are degraded the fastest followed by the gradual removal of the branched alkanes. Cycloakanes and aromatic hydrocarbons are more resistant and disappear at a much slower rate.

Chemical degradation processes of oil during weathering are not well understood. Oxidation affects most readily aromatic hydrocarbons of intermediate and higher molecular weight.

The effect of these slick weathering processes is a general depletion by evaporation and dissolution within 48 - 96 hours of lower boiling fractions with a boiling point below 250°C, and a slower degradation by microbial and chemical oxidation in terms of years for the higher boiling fractions.

Oil incorporated into marine sediments does not undergo the same changes as those observed in oils exposed to the atmosphere because of the absence of dissolved oxygen and the shielding from sunlight. This environment causes the oil to retain its original composition for much longer periods and if the deposit is later distributed by the actions of waves, tidal currents, or dredging, oil which has undergone little degradation will be released. After release, the oil can be moved into other areas where it can cause deleterious effects. Furthermore, the oil re-

leased from sediments may contain pesticides (or their decomposition products) which were originally associated with mineral grains incorporated in the deposits.

d. EMULSION FORMATION

Oil when mixed with seawater tends to form emulsions and depending upon the chemical composition of the oil and presence or absence of other surface active constituents (surfactants), the emulsions may be either oil-in-water (as in milk) or water-in-oil (as in butter). Emulsion formation changes the physical characteristics of the oil and its physical and chemical behavior in the ocean and, therefore, alters its effects on maritime organisms.

Many oils when vigorously mixed with seawater form oil-in-water emulsions. The fine oil droplets are then dispersed through a large volume of water, often disappearing from the ocean surface. In a stable dispersed form, the oil does not "wet" surfaces and also provides maximum surface area for microbial and chemical degradation of the oil. The large surface area also permits soluble constituents in the oil to dissolve more readily in seawater.

e. MOVEMENT AND DISPERSAL OF OIL SLICKS (10)

A volume of oil suddenly spilled on the sea surface spreads horizontally at three different rates, each one determined by a balance of various properties of oil and water. These successive phases of spreading are: an inertia phase, a viscous phase, and finally a surface-tension phase. The duration of each phase depends on the amount of oil initially released. Observations indicate that an oil slick spreads to a certain size and then ceases to spread any further. Various theories have been developed to explain this phenomenon. A plausible explanation is that the hydrocarbon component responsible for last stage surface-tension spreading are lost either by evaporation, or dissolution into the water, to a point where surface spreading is held by uniform surface tension (10).

f. MOVEMENT OF AN OIL SLICK

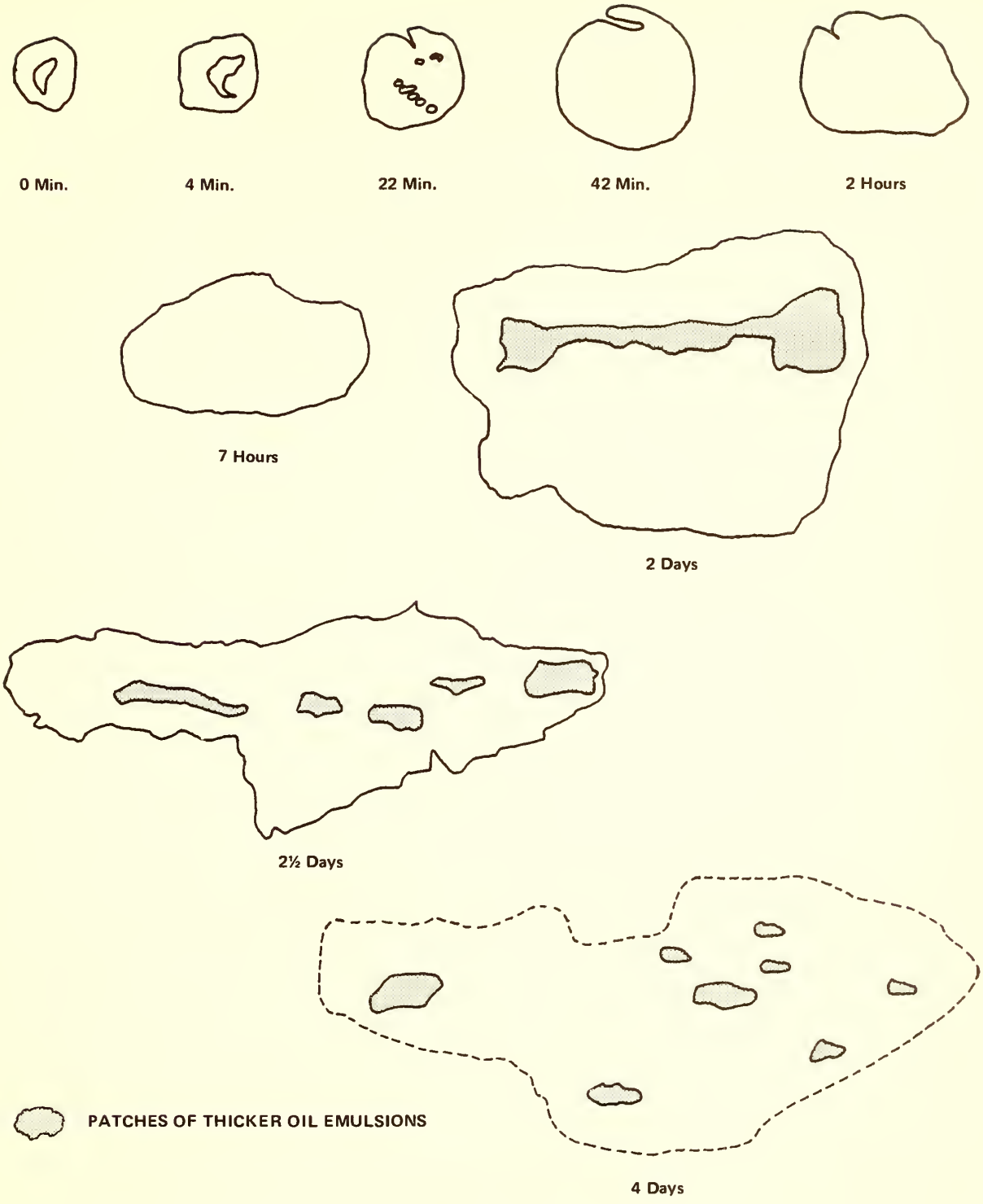
In addition to the well-documented spreading phenomena, an oil spill such as that illustrated in Figure IV-6 exhibits two other important properties. First, during the spreading process, variations in the wind, waves, and current usually separate a large spill into several large patches. The large patches tend to move apart with time. This increases the area of the patch swept by the spill and also increases the rate of dissolution of hydrocarbons into the water. Secondly, waves on the open ocean and the surf near shore cause rapid mixing of the oil and seawater. The tiny suspended oil droplets in the water substantially increase the surface area available for dissolving hydrocarbons into the water and the formation of water-in-oil emulsions and aid in aerosolization. The dynamics of a large spill are illustrated in Figure IV-6.

g. PHYSICAL BREAKUP OF AN OIL SLICK INTO OIL DROPLETS AND SUBSURFACE DISPERSION

The suspension and dispersion of micro oil droplets in seawater is related to the turbulent energy in surface waters. Turbulence is increased when waves break so that winds strong enough to cause whitecaps substantially increase the turbulence of surface waters. The depth to which this wave-induced turbulence penetrates varies, but 30 to 100 feet might be a representative range for the depth of penetration of the strong wave generated surface turbulence. Thus, fine oil droplets dispersed by wind mixing would be most abundant in near-surface waters (less than 100 feet). Mixing of waters caused by strong tidal currents in estuaries can mix oil droplets to much greater depths.

h. SUBSURFACE DISTRIBUTION OF "OIL DROPLETS"

Oil droplets respond to turbulence depending on their size, with a small oil droplet much less than that of a large droplet. Thus, one can expect to find small oil droplets fairly deep, while large droplets should remain near the surface. Increased mixing also increases the depth of droplet penetration into the water.



SPILL SIZE: 120 TONS SPILLED WITHIN 50 MINUTES

SLICK VELOCITY: 3.3% OF WIND SPEED

Figure IV–6 A SERIES OF DIAGRAMS SHOWING THE OUTLINE DEVELOPMENT AND SUBSEQUENT BREAK–UP OF THE OIL SLICK

SOURCE: Large Scale Experiments on the Spreading of Oil at Sea and Its Disappearance by Natural Factors, P.G. Jeffery.

Wind blowing over the water imparts momentum to the surface water and moves it in the direction the wind blows. The motion while the wind blows is of importance because the surface layer of water and associated oil slicks can move substantial distances.

Predictions have been made on oil slick movement due to wind effects by assuming the surface water and winds behave similarly, and that the ratio of the square root of densities of air and water is the factor determining the velocity of the water at the surface with respect to the velocity of the wind measured at a height of about 30 feet. Based on this assumption, the velocity of the surface layer is about 3 percent of the surface wind velocity, although observations of the recent ARGO MERCHANT oil spill have indicated the surface layer velocity is only about 1 percent of the surface wind velocity. (12).

The surface drift as a result of wind has been taken into consideration with respect to the bulk fluid lying under the surface layer. If this fluid is under the action of a current, the net motion will be a vertical summation of the two velocities. Thus, the velocity of slick movement is equal to the current velocity plus 3 percent of the wind velocity. (Since vector quantities are a consideration, both speed and direction must be calculated). This formula has proven to be consistent with laboratory and field observations, with the exception of a recent observation of the ARGO MERCHANT spill.

i. MOVEMENT OF OIL AND OIL SLICKS IN ESTUARIES (13,14)

In an estuary, movements of oil slicks are complicated by the large oscillatory tidal currents and the larger wind induced currents near the shoreline. Therefore, oil spill dynamics in an estuary will behave somewhat differently than it would in the open sea.

In the surface layers, the spilled oil will be extended into an elongated horizontal plume by tidal currents assuming no wind. Through the action of mixing processes previously described, a widespread slick of relatively low concentration will develop on which a relatively narrow plume of higher concentration is superimposed, with each tide.

Tidal currents moving past irregularities in the shoreline further disperse the oil. Intense mixing of oil and surface waters can occur where strong tidal currents move slicks across an irregular bottom such as the sills (submerged ridges) in fjordlike estuaries.

Frequently, eddies associated with embayments or with points of land that project into the estuary will temporarily trap water containing high concentrations of oil as the plume is carried past by tidal currents. Most of the oil is carried on out past the shore feature by the tidal current, while the trapped oil slowly spreads out into the main stream causing dispersal behind the main body of the slick. When the tide reverses, the process is repeated, with a resulting dispersion on the opposite side of the slick.

j. TRANSFER OF OIL FILMS TO THE ATMOSPHERE (15)

Observations of the evaporation and disappearance of oil films from large lakes suggest other important processes may be actively involved in removing oil from the sea-surface and transferring it into the atmosphere. Laboratory studies and open water oil spill studies have shown that a significant portion of a spill is immediately lost to the atmosphere. This phenomena occurs as a result of evaporation of the spill and the creation of aerosols which directly transfer the oil to the atmosphere without a phase change.

Recreation-spawned oil films for example, disappear from the water surface in 70 to 90 hours after boating activity has stopped. There was no spill evidence to indicate that the oils are removed by evaporation, dissolution, or emulsification. Instead it appears that most of the loss occurs by formation of tiny droplets (aerosols) which are injected into the atmosphere.

Laboratory experiments indicate that the combined action of bubbles and ultraviolet irradiation are very effective in removing oily films from the water surface. Exposure to the atmosphere and ultraviolet radiation apparently oxidizes the hydrocarbons in these bubble films. The film materials preferentially pick-up other oil-soluble constituents in

the water. The aerosols are also likely to be colonized by bacteria and other micro-organisms. While the data is inconclusive, the process described may be one of the important processes that cause disappearance of oil slicks in many marine areas.

k. BEHAVIOR OF SPILLED OIL ON SHORE

When an oil slick reaches the shore, its behavior depends on the nature of the oil, its emulsions, seastate and the nature of the shoreline. Usually, much of the oil will be carried to the beach and deposited at the high-water mark by successive tides. Well-weathered or heavy oils mix with sand or plant debris during this process, forming "oil-cakes". These cakes may cause more trouble by sinking into sand and gravel or clinging to seaweeds.

On pebble beaches, oil may sink among the pebbles to a depth of 0.5-1 meter. Oil does not sink as deeply into wet sand. Breakers may, however, throw fresh sand over the oil-containing sand, burying it. In this way a beach may appear clean shortly after an oil slick has come ashore. Later removal of surface layers during storms or in seasonal sand movements expose the oil. Studies of hydrocarbons within sandy beaches interstitial water indicate that hydrocarbons persist for decades after the spill event and do effect the benthic marine organisms.

Because of the many differing beach physiographic features and ecosystems involved, a general oil vulnerability classification system has been devised (16). This classification system is based on a 1 to 10 scale, in order of the increasing ecosystem vulnerability. These beach environs are:

(1) exposed, steeply dipping or cliffed rocky shores,
(2) eroding wavecut platforms,
(3) fine sand beaches,
(4) coarse sand beaches,
(5) exposed tidal flats,
(6) mixed sand and gravel beaches,
(7) gravel beaches,
(8) sheltered rocky coasts,

(9) sheltered tidal flats

(10) salt marshes and mangroves

5. EFFECTS OF OIL ON MARINE ORGANISMS AND ECOSYSTEMS (10, 11)

a. GENERAL

In a continuing effort to evaluate the relative harmful effects of petroleum products to aquatic organisms as set forth by IMCO's Resolution No. 6 of the Marine Pollution Conference of 1973 (MP/CONF/WP. 46), the U.S. EPA conducted investigations to determine the acute toxicity of six petroleum products on four test organisms; also, selected physiochemical properties of water emulsions of the selected oils have been determined. Additionally, a thorough literature review has been conducted to further examine the relative effects of different refined fractions of crude oil. For a detailed analysis of the harmful effects of oil upon marine organisms, see reference (17).

Exposure to oil can affect an organism physiologically and behaviorally. The affects of hydrocarbons on the individual organisms may be generalized as: direct lethal toxicity; sublethal disruption of physiological processes and behavior; effects of direct coating by oil; incorporation of hydrocarbons, causing tainting and/or accumulation of hydrocarbons (including carcinogens) in organisms directly or by food-web-transfer; and changes in biological habitats.

Lethal toxicity (death) can occur when hydrocarbons interfere directly with cellular genetic and subcellular processes, especially membrane activities. Sublethal effects may also involve cellular and physiological effects. Although they do not produce immediate death, sublethal responses ultimately can affect survival of individual organisms, their local population dynamics, and the dynamic equilibria of biotic communities.*

* A population is defined as a group of individuals of the same species inhibiting the same geographic region of the marine environment. A community is defined as a group of populations occupying the same regions or biotic zone in a region.

Important in this category are disrupted behavior, higher susceptibility to disease, reduced photosynthesis, reduced fertility, and abnormal cellular development.

Coating is generally associated with the high-boiling fractions of oil, i.e., weathered oil. It can be a problem for intertidal marine species, eggs and larvae, sessile species, plankton, and birds and mammels. Mobile organisms would seem to have the capacity to avoid prolonged exposure, but they are physiologically affected by minute amounts of fouling. Subtidal benthic species are somewhat protected from coating because oil does not occur as a film on subtidal substrate except in the worst local spill situations.

The incorporation of hydrocarbons, including carcinogens, is of particular concern because they can be accumulated in marine organisms and be transferred to other organisms through the food web. Both tainting and accumulation of hydrocarbons can occur in marine organisms exposed to oil. Oil entering a salt marsh, for example, is found in and on virtually all marine organisms. Once exposure is terminated, however, with time some species have recovered completely.

Significant shifts in composition and distribution of species can occur in a spill area when the habitat is changed so as to become unsuitable or less suitable to a certain specie or species. Intertidal and subtidal benthic species are, therefore, important subjects. How much and what kinds of oil prevent a species from utilizing a substrate, for example, is largely unknown; but in view of available data, the presence of low to medium boiling point aromatic hydrocarbons at concentrations as low as 10 to 100 parts per billion may chemically perturb many species. The effects of higher boiling, insoluble materials depend on how much an organism relies on its particular substrate and how much it is altered by oil. Species depending on a substrate only for passive support may be little affected by habitat changes caused by the oil. But those living

in the substrate or otherwise actively depending on the substrates physical properties are surely more vulnerable. Still other effects are acclimation and selection, processes that may alter how individuals and populations tolerate concentrations of oil. Table IV-12 lists the sensitivities of selected species to oil.

Table IV-13 is an assessment of toxic sensitivities of adult and larval stages of marine organisms. The available data indicate that death may be expected in most adult marine organisms from exposure to 1 to 100 parts per million of total soluble aromatic hydrocarbon derivatives (SAD) within few hours' exposure. For larvae, lethal concentrations may be as low as 0.1 parts per million of SAD. These lethal concentrations can result from unweathered oil slicks. Soluble aromatic hydrocarbon derivative concentrations of 10 to 100 parts per billion have been demonstrated to interfere with chemical sensing and communications on which lobsters and anadromous fish depend.

The effects of oil on local populations may be examined by considering parameters such as population size and age distribution, and whether the spill is an isolated accidental event or the result of chronic discharges. Accidental spills are comprised of three general stages: (1) prespill equilibrium, (2) immediate postspill impact, and (3) recovery to equilibrium conditions. In contrast, a continuous discharge results in sublethal oil contamination, which may not produce immediate, dramatic impacts, but may instead show subtle, long term effects.

Biological effects are determined by the following factors:

- Type of oil spilled, in particular, the concentration of lower boiling aromatic hydrocarbons.
- Amount of oil
- Physiography of the spill area
- Weather conditions at the time
- Biota in the area
- Season of the year
- Previous exposure of the area to oil
- Exposure to other pollutants
- Method of treatment of the spill

Table IV–12
EFFECTS OF OIL ON SELECTED SPECIES [1]

SPECIES	COMMON NAME	LETHAL	SUBLETHAL	COATING	UPTAKE AND TAINTING	HABITAT CHANGE
BIRDS						
Rissa tridactyla	KITTIWAKE			X		
FISH						
Alosa spp.	ALEWIFE	X				
Clupea harengus	HERRING	X				
Fundulus heteroclitus	MUMMICHOG	X				
Gadus morhua	ATLANTIC COD	X				
Micropogon undulatus	CROAKER		X			
Morona saxatillis	STRIPED BASS		X			
Pseudopleuronectes americanus	WINTER FLOUNDER	X	X			
CRUSTACEANS						
Acartia spp.	ZOOPLANKTON	X				
Ampelisca vadorum	AMPHIPOD	X				X
Balanus balanoides	ACORN BARNACLE	X				
Calanus spp.	ZOOPLANKTON	X			X	
Crangon spp.	SHRIMP	X				
Emerita spp.	MOLE CRAB	X				
Homarus americanus	AMERICAN LOBSTER	X	X			
Paqurus longicarpus	HERMIT CRAB	X			X	
Pandalus spp.	SHRIMP	X				
MOLLUSKS						
Asquipecten spp.	SCALLOP		X		X	
Crassostrea spp.	VIRGINIA OYSTER	X	X		X	
Donax spp.	COQUINA CLAM	X				
Mercenaria mercenaria	NORTHERN QUAHOG	X				
Modiolus spp.	HORSE MUSSEL		X		X	
Mya arenia	SOFT SHELL CLAM	X			X	X
Mytilus edulis	EDIBLE MUSSEL	X	X	X	X	
Littorina littorea and spp.	PERIWINKLE	X	X	X		
Nassarius obsoletus	COMMON MUD SNAIL		X			
Thais labillus	DOG WHELK	X	X			
WORMS						
Arenicola marina	LUGWORM	X	X			X
Nereis virens	CLAM WORM	X				
Stroblosoio benedicti	POLYCHAETE	X				

Table IV–12
EFFECTS OF OIL ON SELECTED SPECIES [1]

SPECIES	COMMON NAME	LETHAL	SUBLETHAL	COATING	UPTAKE AND TAINTING	HABITAT CHANGES
OTHER ANIMALS						
Asterias vulgaris	STARFISH				X	
Strongylocentratus drobachiensis	SEA URCHIN	X			X	
PLANTS						
Juncus gerardi	MARSH RUSHES	X				
Spartina alterniflora	MARSH GRASSES	X				X
Spartina patens	CORD GRASS	X				
Laminaria spp.	KELP	X				

[1] DOES NOT LIST ALL SPECIES FOR WHICH DATA HAVE BEEN REPORTED. RATHER, AN X REPRESENTS REPORTED DATA FOR THOSE SPECIES WHICH WERE SELECTED FOR SPECIAL CONSIDERATION. AN X INDICATES THAT SOME DATA, REGARDLESS OF NUMBER, HAVE BEEN REPORTED.

SOURCE: The Massachusetts Institute of Technology Department of Civil Engineering, 1974, "Atlantic/Alaskan OCS Petroleum Study: Primary Biological Effects," prepared for the Council on Environmental Quality under contract No. EQC330.

Table IV–13
ESTIMATED TOXICITY SENSITIVITY
(Parts per million)

CLASS	ESTIMATED CONCENTRATION OF SOLUBLE AROMATICS CAUSING TOXICITY
PLANTS	10 – 100
FINFISH	5 – 50
LARVAE (ALL SPECIES)	0.1 – 1
PELAGIC CRUSTACEANS	1 – 10
GASTROPODS (SNAILS, ETC.)	10 – 100
BIVALVES (OYSTERS, CLAMS, ETC.)	5 – 50
BENTHIC CRUSTACEANS (LOBSTERS, CRABS, ETC.)	1 – 10
OTHER BENTHIC INVERTEBRATES	1 – 10

SOURCE: The Massachusetts Institute of Technology Department of Civil Engineering, 1973, "A Preliminary Assessment of the Environ mental Vulnerability of Machias Bay, Maine to Oil Supertankers", prepared for the Council on Environmental Quality (NTIS Accession No. COM 73-10564).

b. EFFECTS ON BIRDS

Many dead sea birds have been observed after most spills of crude and heavy fuel oils. The death toll has usually been estimated by counting the number of oiled birds washed onto beaches, but these estimates often do not include dead birds not reaching shore. The primary effect of oil on birds has been the fouling of the small barbules which causes a disruption of the insulation and buoyancy and flight characteristics of the feathers. Birds,in turn, may sink and drown, or may rapidly lose body heat and succumb to pneumonia. Fouled birds exhibit excessive preening, which may disrupt normal feeding activity or result in ingestion of oil. Ingested oil may poison the birds through inflammation of the digestive tract or disturb other physiological processes. Birds in which the insulating ability of the feathers has been damaged develop a very high metabolic rate to compensate for the rapid loss of body heat. This, coupled with a cessation of feeding, may lead to "accelerated starvation". Oiled birds may not lay eggs as usual and oiled eggs may not hatch.

Some species of sea birds are more susceptible to oiling than others. Diving sea birds suffer inordinate mortalities, whereas other types, such as sea gulls and shearwaters indicate oil avoidance tendancies. There have been reports that the more susceptible species are those that are attracted by the oil slick and land on it. Another important factor is that these diving birds, which may remain submerged for several minutes, may surface under oil slicks.

During the Santa Barbara incident, loons and grebes, which comprise 7 to 10 percent of the total bird population, suffered 64 percent of the mortality. Many of these sea birds have long lives and breed slowly; thus the recovery of a population may be a very slow process (18). Because of migratory behavior, a large proportion of a bird species may often be concentrated in a small area. Oil spillage in this area would severely reduce the population. The jackass penguin currently faces extinction because the species is restricted to South Africa and is gradually being killed off by floating oil emanating from tankers rounding the Cape of Good Hope (19).

c. EFFECTS ON MAMMALS

Little is known about the effects of oil pollution on mammals, although it is recognized to be less serious than on birds. Serious concern was expressed for the sea lions and elephant seals of Santa Barbara's Channel Islands, and for the migrating endangered grey whales and other mammals along the East and West Coasts of the United States. Despite confusing public reports, there is no conclusive evidence that any of the coated mammals were killed directly by the Santa Barbara oil spill (20,21).

Mammals have been affected by some spills (22). Possible effects include suffocation by oil, disruption of insulation abilities of fur coats, and poisoning from ingested oil. In addition to pinnipeds (seals, walruses, etc.) and cetaceans (whales and dolphins), other mammals occupy coastal marine habitats. Sea otters are recovering from near extinction along the West Coast of the United States. Commercially valuable fur bearers, mainly muskrats, inhabit coastal wetlands in Louisiana and are susceptible to oil pollution from the production fields, although fur production has not declined.

d. EFFECT ON FISH AND SHELLFISH (11)

There is a great deal of experimental and field evidence indicating that refined oil products and components are quite toxic to fish and shellfish. Fish may be more resistant than some other marine organisms because their surfaces, including gills, are coated with a slimy mucus that is an oil repellent; and evidence suggests that fish may simply migrate away from an area affected by large oil concentrations (23,24).

Recent data from the ARGO MERCHANT spill indicated selective cytogentic and cytological impacts on pelagic fish eggs. There has been concern that larval fish, which often concentrate at the ocean surface, may be adversely affected by floating oil, either through toxicity or entrapment (22,25,26).

Numerous deaths among these young forms could have serious consequences for adult populations over the long run, and such consequences may be difficult to detect, although a recently developed physical model (27) suggests that they would be minimal. Also unknown are the long-term

effects of trace contamination of fish through feeding. Many fish feed on benthic invertebrates that may contain petroleum hydrocarbons. Others, such as mullet, feed on organisms and detritus at the water's surface, where there may also be hydrocarbon concentrations. Mullet in some Australian coastal waters close to port and refinery facilities are frequently contaminated with petroleum hydrocarbons and have a characteristic odor and chemical composition similar to kerosene (28, 30). Similar situations to this are found along certain U.S. inland waterways.

e. FISHERIES (11)

Oil pollution may affect the use of commercial species of fish mollusks, and crustaceans. Even though no direct effects of oil on fish were observed in Santa Barbara Channel (24,30), the risk of fouling fishing gear or catching contaminated fish severely reduced fishing effort. This had an economic impact on the local fisherman, even though the resource was not directly affected (31).

Tainting of commercial species of fish (22), clams (32), oysters (33) and mussels (22) by oil has been reported. Tainting can result in a loss to commercial fisherman because of unsaleable catches. Tainting may be quite persistent, the noticeable taint lasting several months. Furthermore, Blumer, et al. (34) have indicated that oysters affected by the West Falmouth spill, but subsequently kept in clean water, retained petroleum hydrocarbons similar in chemical composition to the Number 2 Fuel oil spilled over eight months ago. Based on these findings, authorities imposed a total ban on the taking of shellfish in a large area. A partial ban still exists more than three years after the original contamination.

More recent research indicates that shellfish and fish (35) will accumulate hydrocarbons, but will cleanse themselves if maintained in uncontaminated seawater for several months. The mechanisms of uptake and of decontamination are complex and varied and the time required for decontamination would be expected to depend on: the duration and dosage of exposure, storage sites, possession of metabolic processes to detoxify the hydrocarbons, and on the organisms' physiological state and other

factors.

Attempts have been made to demonstrate the effects of oil spillage on fishery productivity as reflected in commercial catch statistics. Notable among these was a study undertaken along the coast of Louisiana, which supports very large and important commercial fisheries as well as a highly developed petroleum industry. Statistics showed no decline in catches of shrimp, crabs, and fish concomitant with the development of the petroleum industry (36). A decline in the oyster harvest coincident with the expansion of the petroleum industry in the 1940's has been attributed to an oyster disease and not oil. These study results should be used cautiously since they do not represent precise reporting, because they fail to take into account the changing effort and technological advances of fisheries and are generally not available for the localized areas in which pollution may be intense.

In the Gulf of Mexico, where oil and gas operations have continued for 25 years, no significant long-term changes in fish catch have been noted. However, the record catches of 1954 have never been exceeded, and recent studies at Texas A & M Univeristy indicate that the fish catch has remained high as a result of the increased effort. Shrimp catches in the last few years have been declining both in total catch in waters and catch per effort (37).

The long history of oil production on the Gulf Coast has not indicated that significant impacts on the gulf fisheries has resulted, but the data is inconclusive on the possibility of important local effects.

f. EFFECT ON PLANKTON

Few observable effects of oil spills on the small, passively drifting plants and animals composing plankton have been uncovered in post-spill investigations. Some kills were observed during the Torrey Canyon spill among phytoplankton (plant plankton), but none among the zooplankton (animal plankton). It was found that the heavy use of chemical dispersants complicates the issue. Studies following the Santa Barbara Offshore oil rig blowout could detect no harmful effects on phytoplanktonic

productivity (38) or zooplankton populations (39). However, because plankton is passively carried about by water currents, it would be very difficult to discern effects in the field especially in open waters like the Santa Barbara Channel. Zooplankton surveys following the ARGO MERCHANT spill found mandibular contamination and oil present in the gut and natural oil storage areas. Laboratory experiments have generally produced more tangible results, although the degree to which these results may be extrapolated to natural conditions is open to question. These results indicate that there is a possibility of both stimulation and inhibition of photosynthesis in areas subject to chronic oil pollution or in the immediate vicinity of a heavy oil spill.

The larvae or young of many benthic and fish species spend time as members of the zooplankton. They are often much more susceptible to toxicants than adults. Larvae of the intertidal barnacle (Elminius modestus) were shown to be killed by 100 parts per million (ppm) of fresh crude oil (40). Crude oils have also been shown to be toxic to the planktonic eggs and larvae of some fishes, including cod and herring (41).

In addition to potentially acute effects of oil spills on planktonic organisms, there has been concern about the long-term effects of floating oil and tar lumps, which have become alarmingly common on the high seas. If the concentrations of petroleum hydrocarbons in ocean surface waters are being increased by shipping discharges or atmospheric input, there would certainly be concern for the near-surface plankton so important to oceanic productivity. Data on hydrocarbon concentrations in seawater are remarkably scant and historical data are nonexistent, thus making it impossible to predict future trends and effects of oil on the oceanic ecosystem.

g. EFFECTS ON NEUSTON (11)

Neuston is the assemblage of organisms which live right at or within 5 to 10 centimeters beneath the surface of the sea. Some research is now in progress in Bermuda on the effects of floating oil on the Sargassum community. Unfortunately, the ecology of neustonic organisms is very poorly known, and the effects on it of floating oil can only be surmised.

However, it can be generally felt that if the oil sheen is visible, the fouling potential from the dissolved and dispersed oil fractions would be sufficient to eradicate or severely impact this community.

h. EFFECTS ON INTERTIDAL ORGANISMS (11)

Spilled oil has its most visual effects on the intertidal environment. Oil may smother, foul, or directly poison, intertidal organisms. Reports of the effects of direct oil poisoning vary from "non-existent" to "extremely damaging". The differences seem in part due to the type of oil spilled, which determines both the toxicity and the degree of contact with fresh oil slicks. Even crude oils differ in their toxicities to intertidal organisms (24).

General oil spill impacts have varied from slight to moderate, and the communities have partially recovered within a few years. The resistance and resilience to oil is attributed to: (1) the hardiness of intertidal organisms, (2) their rapid reproduction, and (3) the relatively rapid removal of oil from the intertidal zone by waves. The use of cosmetic clean-up techniques - such as toxic dispersants, steam cleaning and straw on certain oiled shores has been demonstrated to cause greater mortality or slower regrowth. Most biologists who have experience with the effects of such techniques recommend no attempt at removal unless clearly necessary, and then only with absorbents or by scraping away oily sand (11). Investigations of the beach self-cleaning processes and the biological recovery of the bunker C spill in Chedabucto Bay in Nova Scotia are shown in Figure IV-7. This figure indicates the intricacies of the beach as well as the species involved in analyzing the beach recovery processes. As indicated the vegetal species, Kelp Fucas visiculosus and salt marsh cordgrass Spartina atteniflora showed a moderately rapid recovery whereas the soft shelled clam Mya Arenaria was still being impacted by the beaches interstitial water hydrocarbon content.

i. EFFECTS ON SEABED ORGANISMS (11)

Oil has a distinct affinity for sediment particles, especially clay

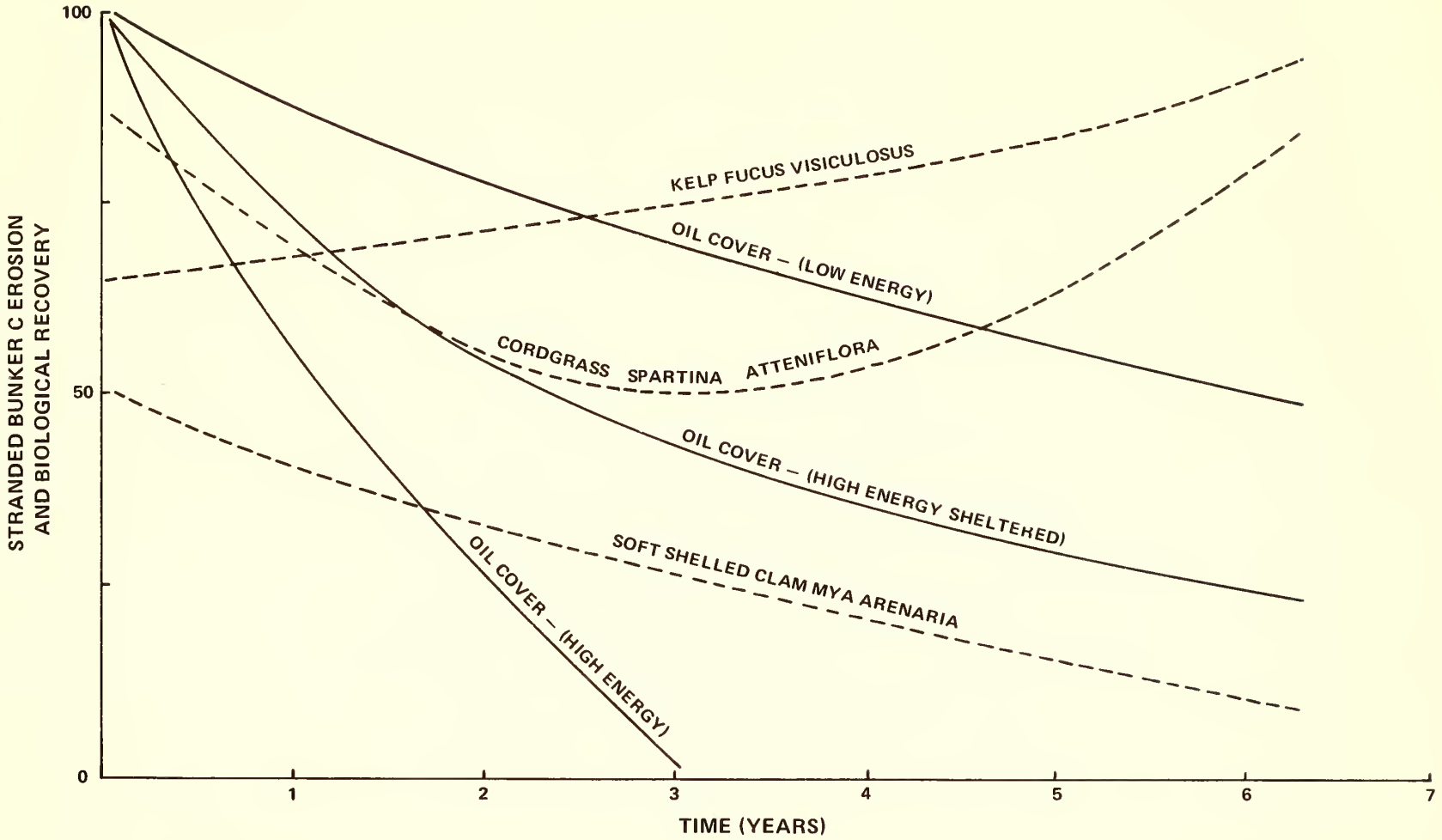


Figure IV–7 SUMMARY OF SELF-CLEANING AND BIOLOGICAL RECOVERY PROCESSES FOR CHEDABUCTO BAY SHORE ZONE, 1970–1976

SOURCE: Vandermulen, John H., The Chedabucto Bay Spill, Arrow, 1970, Oceanus, Vol. 20 No. 4, Fall 1977.

minerals and particles coated with organic matter. Oil is often deposited in high concentrations on the bottom, where it may persist and chronically repollute an environment. Biodegradation and other weathering processes result in a selective loss of n-alkanes so that the relative composition of the oil persisting in sediments changes markedly as the total quantity of oil is reduced (34). The net effect is that the hydrocarbons remaining are rich in aromatics and cycloalkanes which may continue to be harmful in a quiescent environment for centuries. Measurements taken after the Argo Merchant spill found sediments hydrocarbon concentrations up to 100 ppm within 10 miles of the grounding. This caused a reduced respiration rate in scallops and mussels.

Marine organisms may accumulate petroleum hydrocarbons in their tissues. This may be especially true for benthic organisms, many of which feed on suspended matter or bottom sediments which may contain oil. The chronic effects of such contamination remain unstudied, and it is unknown if petroleum hydrocarbons can be transmitted to fish feeding on oil-contaminated seabed organisms.

j. IMPACT ON WETLANDS (14)

The great value of tidal wetlands in coastal ecosystems is generally accepted, if not always well understood. Tidal wetlands are characteristic of many estuarine shores throughout the world and include salt marshes dominated by grasses in temperate climates, and mangrove swamps dominated by trees in the tropics. They serve as habitat, feeding, or nesting grounds for shore birds, fish, and other wildlife; consequently they are considered the most vulnerable ecosystems for oil spill impacts.

The amount of impact damage to the wetlands is a function of the type and amount of oil, the plant species involved and the time of year. In the case of oil pollution, salt marshes often suffered only minimal damage and have also alleviated the pollution problem by trapping and holding oil.

The general short term impact of oil on marsh ecosystems is the fouling of the flora and fauna, which, in turn, results in the destruction of the fouled plants stems within several days and the drastic reduction of the indigenous fauna. Over long periods there is an extended recovery time in which the salt marsh plants recover as a result of the new growth from the viable root stock. This process appears to be specie site and seasonally specific. A general guide to salt marsh plants susceptibility to oil spillage is shown in Table IV-14.

k. IMPACT ON THE SUBPOLAR MARINE AND POLAR MARINE ENVIRONMENT (11)

The tapping of oil resources in the North American Arctic and the environmental consequences of the Trans-Alaska pipeline have received much public attention. Alaskan oil will continue to be transported by sea, from the warm water port of Valdez to the lower 48 states, but as pipeline flow rates increase, larger tankers will probably be employed. Because of the hazards of navigation in these waters, there is a significant possibility of massive oil spills in the subpolar marine environment. The effects of spilled oil in polar regions might be serious and long lasting (42) because: (1) cold temperatures do not permit rapid evaporation of aromatics in oil, thereby allowing more of the toxic hydrocarbon components to enter solution in sea water even though the solubility of these compounds is lower at low temperatures; (2) the rate of bacterial degradation and other natural weathering processes are comparatively slower at the colder temperatures; and (3) the marine biota of polar regions are generally long-lived, have low reproductive potentials and do not have wide ranging dispersal stages (43).

A large oil spill in the North American Arctic might have considerable effects: (1) the oil would persist and remain toxic for a long time, and (2) recovery of an affected area through recolonization would be slow. These potential impacts should be considered in light of the relative inefficiency of spill prevention and control techniques in such a difficult environment.

Table IV–14
SALT MARSH PLANTS SUSCEPTIBILITY TO OIL SPILLAGE

GROUP	SUSCEPTIBILITY	REASON FOR DAMAGE
1	VERY SUSCEPTIBLE	SHALLOW ROOTING PLANTS WITH NO OR SMALL FOOD RESERVES; QUICKLY KILLED BY OIL AND CANNOT RECOVER; e.g., Suaeda maritima (SEABLITE); SEED–LINGS OF ALL SPECIES
2	SUSCEPTIBLE	SHRUBBY PERENNIALS WITH EXPOSED RANCH ENDS WHICH ARE BADLY DAM–AGED BY OIL; e.g., Ialiminoe porticulacoides (SEA PURSLANE)
3	SUSCEPTIBLE	FILAMENTOUS GREEN ALGAE. THOUGH FILAMENTS ARE QUICKLY KILLED, POP–ULATIONS CAN RECOVER RAPIDLY BY GROWTH AND VEGETATIVE REPRODUC–TION OF ANY UNHARMED FRAGMENTS OR SPORES
4	INTERMEDIATE	PERENNIALS WHICH USUALLY RECOVER FROM ONE SPILLAGE OR UP TO FOUR LIGHT EXPERIMENTAL OILINGS, BUT DECLINE RAPIDLY IF CHRONICALLY POLLUTED; e.g., Spartina anglica; Puccinellia maritima (SEA POA)
5	RESISTANT	PERENNIALS, USUALLY OF ROSETTE FORM, WITH LARGE FOOD RESERVES (e.g., TAP ROOTS). MOST OF THEM DIE DOWN IN WINTER. SOME HAVE SUR–VIVED TWELVE EXPERIMENTAL OIL–INGS; e.g., Armeria maritima (THRIFT)
6	VERY RESISTANT	PERENNIALS OF GROUP 5 TYPE WHICH HAVE IN ADDITION A RESISTANCE TO OILS AT THE CELLULAR LEVEL; e.g., MEMBERS OF THE Umbelliferae.

SOURCE: Baker, J.M., Crapp, C.B., The Biological Effects of Oil Pollution on Littoral Communities Including Salt Marshes, Marine Pollution and Sea Life, United Nations FAO 1972.

1. IMPACT ON ESTUARIES (11)

Estuaries are extremely productive and valuable ecosystems and are often subjected to the intense pressure of multiple uses by man. The estuaries are expected to assimilate domestic and industrial wastes and accommodate marine transportation, yet continue to remain productive in fish and shellfish. Because of the increasing trend toward tanker-transported crude and refined oils and the proximity of estuaries to population centers, estuaries must cope with increasing levels of petroleum pollution and industrial and domestic effluents. Thus, certain estuarine environments may be subjected to frequent small spills, often of more toxic refined products or continuous low-level additions from refineries, petro-chemical plants, oil field wastes, and even domestic sewage and urban runoff.

Because estuaries are generally confined and relatively shallow bodies of water, oil spills can be spread by successive tidal stages over much of the water's surface and have little chance to be swept to sea. In all spill cases there is a high likelihood that the oil will reach large portions of the shoreline and pollute the bottom. Estuaries are typically turbid, and therefore oil will be absorbed onto fine sediment particles and sink to the bottom, where it will contaminate bottom-dwelling organisms, including shellfish and bottom-feeding fish. This process seemed to be the principal cause of the widespread contamination following the West Falmouth oil spill (44). The oleophilic nature of detritus, which is typically abundant in estuaries, increases the probability of ingestion of oil by estuarine detritivores. If oil is deposited in sediments, it will persist for long periods under the anaerobic conditions typical of subsurface estuarine sediments.

The abundant microbial biota of estuaries ensures that aerobic degradation will be rapid, leading to an intermediate recovery rate. With the great reproductive potentials typical of most estuarine organisms, population shifts and specie recruitment would immediately begin to reestablish the ecosystem. Clearly this is one aspect of the oil pollution problem where full assessment of the biological problems depends on sound information on the fate of the introduced oil, particularly on the degree

to which oil finds its way into estuarine sediments and on the changes in amount and composition of oil in sediments.

The intertidal areas of estuaries are often characterized by extensive tidal wetlands - salt marshes in temperate latitudes and mangrove swamps in the tropics. These are thought to be in large part responsible for the very high productivity of estuarine environments and are a mainstay of the detritus-based estuarine food chain. Wetlands are vulnerable to dosage by floating oil. Although most experimental evidence shows that marsh grasses suffer little from a single dosage of oil (45), oils as different as the light Number 2 fuel oil and the heavy Bunker C fuel oil have caused lethal damage to marsh plants at West Falmouth (46) and Chedabucto Bay, Canada (47). Furthermore, chronic pollution - such as in the vicinity of a refinery effluent or near an oil handling facility - can kill off marsh plants leaving the area susceptible to erosion (48,49).

m. IMPACT ON THE SURVIVAL OF LOCAL SPECIES (10)

A local species population has recovered from an oil spill when it recolonizes and density and age distribution return to prespill levels.

Recovery is not considered complete until prespill size and age distributions have been restored, with allowance for natural fluctuations. This strict criterion does not reflect complete recovery that might occur in more complex situations. For example, the ecological successions involved in local population or community recovery might result in a new equilibrium that differs qualitatively or quantitatively from prespill conditions. The difference does not necessarily indicate degradation or lack of recovery.

Four major stages of population recovery can be identified: (1) assuming survival of part of the original population, recovery begins with survivors; (2) colonizers enter the recovery area; (3) colonizing individuals settle or otherwise reestablish; and (4) recovery is completed. In annual species, recovery occurs when prespill population density is reached; recovery in perennial species is equated with return to a prespill stable age distribution within the local population.

"Wide-dispersal ubiquitous species", the most common marine biotic category, are the populations whose prespill habitat is accessible to reinvading members of the species in a single reproductive season and who number enough "immigrants" to replace local prespill populations. Recovery time is of the order of the life spans of individual organisms.

"Wide-dispersal non-ubiquitous species" are the populations whose prespill habitat is accessible to reinvading members of the species in a single reproductive season but who may not have enough settlers to repopulate the local area quickly. This category may be vulnerable to occasional biotic catastrophes (occasions of high adult mortality). Birds are in this group; their recovery time, though largely unknown, is highly variable.

"Non-wide dispersal species" are populations whose prespill habitat is not accessible to reinvading members of the species. Some snails are an example. Recovery times are likely to be longer than the life spans of the species. This group is very sensitive to catastrophic spills because it takes longer than other categories to repopulate a decimated zone.

"Highly mobile species," like finfish and birds, appear significantly vulnerable only during highly localized breeding or other types of aggregations at various times of the year or during certain life stages. The significance of such a threat is extremely difficult to project. Planktonic organisms and diving birds are potentially more vulnerable to exposure to oil in the open sea than nektonic organisms, which can swim about. However, a single oil slick should not threaten an entire planktonic population.

Species with small or local breeding populations such as anadromous fish native to a particular river - the alewife, striped bass, and salmon - may be especially vulnerable.

n. EFFECTS OF MASSIVE OIL SPILLS

In view of the number and size of Title XI program tank vessels en-

gaged in domestic trade, it is necessary to consider ecological effects of massive oil spills resulting from a tank vessel casualty and complete loss of cargo. In other words, consider the maximum credible accident.

(1) First Massive Oil Spill. The TORREY CANYON which grounded on March 18, 1967 was the largest spill recorded, releasing approximately 110,000 tons of crude oil in three separate spills; the largest was about 50,000 tons which was released when the ship broke up on March 26, 1967 (50).

In the TORREY CANYON incident, an estimated 100,000 tons of crude oil came ashore on the Cornish beaches after having been at sea for about a week, and polluted about 140 miles of rocky shore and headlands (51). Some of the smaller coves were protected. An unknown quantity of oil came ashore after April 1967, on the beaches of Brittany, polluting about 75 miles of coastline. This oil had been at sea for about two weeks. Oil from the TORREY CANYON was also identified in the Bay of Biscay in early June 1967, about six weeks after the last major release (50).

(2) Recent Massive Oil Spill in U.S. Waters (16). There were several spill incidents that received national attention during December 1976. The most notable incidents were the grounding and break up of the ARGO MERCHANT and the explosion of the tanker Sansinena in Los Angeles (9 persons killed and 50 injured). During the same period of time there were several accidents, although on a smaller scale, occurring in the Thames River in Connecticut, the Delaware River in Pennsylvania, the Hudson River in New York and in Buzzards Bay Massachusetts. These accidents occurred in U.S. Waters; however, most of the vessels involved were of Liberian registry.

The ARGO MERCHANT grounding and subsequent breakup was the largest spill to occur from a vessel in or near U.S. waters (7.6 million gallons of number 6 fuel oil). It ran aground southeast of Nantucket Island, nearly 25 miles off course. The 23 year old 640 foot Liberian flag vessel had a record of eighteen previous accidents. One of the causes of the grounding on December 15, 1977 was thought to be navigational error. The following navigational equipment was found inoperative:

- radar (broken)
- gyro compass (in error)
- radio direction finder (Improperly calibrated)
- echo sounder (not operating)

The short term biological impact of this spill was minimal because of several fortunate events:

- Oil did not float onshore
- A significant amount of oil did not sink and contaminate the bottom
- The incident occurred during the cold winter when fishing and biological productivity is low

Studies conducted at the spill site indicated the rapid weathering of the number 6 and 2 stock occurred, forming a thick "pancake" slick as the oil weathered further. Maximum oil concentration found 1.8 to 3.6 meters beneath the slick were 250 parts per billion (PPM). Within this zone the pelagic fish eggs were found to be intermixed with the higher hydrocarbon levels. Fish eggs of several commercial species were collected in the area. These eggs immediately beneath the spill had oil droplets adhering to the membrane in varying amounts which was specie specific. Laboratory analyses found cytological and cytogenetic impacts the same as on the developing eggs. The total impacts on the rich fishery as a result of this spill is difficult to quantitatively determine. Fish which spawn over wide ocean areas would be expected to suffer some minor population declines, but the species as a whole would not be expected to suffer substantial declines as a result of one isolated event in an open ocean system (26).

Further studies will have to be conducted to determine the long term impact of the spill.

The environmental impact of massive oil spills is variable depending upon the location of the incident and other environmental factors. As previously discussed, the coastal zone is more vulnerable because of its relatively high biological productivity, while offshore incidents

will receive less damage. The season in which the spill occurs would also influence the extent of biological damage (16). A spill will cause biological damage during the spring reproductive period or during the growing season. In addition, the toxicity of the petroleum crude or product varies depending upon its hydrocarbon components. The volatile components of petroleum are usually the most toxic and evaporate rapidly to the atmosphere. Other factors which influence the environmental impact include winds, wave action, tides, and currents.

From these large spills, it can be concluded that the pollution from a massive spill will be widespread, although discontinuous, in those parts of the coastal ocean where currents and wind effects may move the oil within a period of a few weeks.

Drawing on an admittedly inadequate data base, it is most difficult to predict and evaluate the environmental impacts of a massive oil spill. The brief analysis herein depends on scaling up of observed effects from major oil spills. For physical and chemical effects, this strategy may be adequate. The size of the oil slicks and the amount of soluble hydrocarbons dissolved in the ocean are probably directly related to the amount of oil spilled. Likewise, the movement of the slick can be calculated using data on currents and winds in a relatively simple computer program.

Biological effects are not so readily scaled. The area covered by an oil spill will be determined by the amount of oil spilled, as influenced by the amount lost at sea or weathered in various ways as discussed in previous sections, but many questions related to possible threshold effects remain unanswered. For example, if all the wetlands in an entire coastal region are covered with oil causing major mortalities among birds, mammals, and invertebrates; can these wetlands eventually recover? Much more work is needed to assess the long term impact of large spills and the recovery of the marine environment before such questions can be answered. In short, an adequate assessment of ecological effects of a massive oil spill is not yet possible. Still it is possible to indicate in a qualitative way some of the probable effects of a massive oil spill from a Title XI program Tank Vessel engaged in domestic trade.

(3) Ecological Impact Of Spills In U.S. Waters. In order to assess possible ecological impacts of a massive oil spill in U.S. coastal and inland waters from the complete loss of a tank vessel, it is necessary to delineate the waters likely to be affected by such spills. The coastal limits of coastal circulation cells in which currents and winds are capable of moving large oil slicks within a few weeks must be determined; however, the coastal ocean circulation around the United States is poorly known. The current patterns are complicated and subject to seasonal changes in strength and direction in response to winds and river runoff.

Major coastal circulation cells may be delineated as follows:

Atlantic Ocean

- Gulf of Maine - Bay of Fundy to Cape Cod, Massachusetts
- Middle Atlantic Bight - Cape Cod to Cape Hatteras, North Carolina
- South Atlantic Bight - Cape Hatteras, North Carolina to Miami, Florida
- South Florida - Miami, Florida to Sanibel Island, Florida (Fort Myers, Florida)

Gulf of Mexico

- East Gulf of Mexico - Sanibel Island, Florida to Mobile, Alabama
- Mississippi Delta - Mobile, Alabama to Morgan City, Louisiana
- Western Gulf of Mexico - Morgan City, Louisiana to Rio Grand River, Texas

Pacific Ocean

- Hawaiian Islands
- Southern California Bight - U.S. Mexico border to Point Conception, California
- Central California Cession - Point Conception to Cape Mendocino, California

Oregon - Washington Coast - Cape Mendocino, California to Strait of Juan de Fuca
Gulf of Alaska - South of the Aleutian Islands
Bering Sea - South of Cape Prince of Wales

The effects of a massive oil spill in each of these areas can be expected to be different. To illustrate these effects and their magnitude, this section will briefly sketch the probable environmental impacts of a massive oil spill for five differnet areas described above: Gulf of Maine (Machias Bay); Middle Atlantic Bight; Gulf of Mexico (Louisiana); Southern California Bight and Puget Sound.

(a) Gulf of Maine (Machias Bay, Maine) If a tank ship were to lose 150,000 tons of oil in the coastal waters adjoining Machias, Maine, a massive slick would form. The thickness of a slick would depend on the type of crude oil being carried. Assuming such a slick formed, the 150,000 tons of oil could form an emulsion (80%) that would cover about 20 square miles about one-half an inch thick. If the oil formed only a thick slick of a few microns, it could cover about one square mile for each ton of oil or about 150,000 square miles (50). This last possibility seems unlikely in rough sea conditions because of the rapid cleaning of the sea surface by aerosol transfer (52) and other decomposition processes as previously discussed. The slick would be moved along the coast by winds and coastal currents.

If the effects of winds are ignored, the non-tidal currents in spring would carry the oil southward along the coast at about a half knot or about 15 statute miles a day. Within two weeks, the oil slick could reach the vicinity of Boston and Massachusetts Bay. Some of the oil might be carried around Cape Cod but it seems unlikely that large quantities would move south of Cape Cod to enter the Middle Atlantic Bight. (Winds from the south could well move the slick into the Bay of Fundy within a few days following the spill). In either case, 200 to 300 miles of New England shoreline would be potentially exposed to heavy oil pollution. The most immediate effect of the slick would be to kill thousands of seabirds in the Gulf of Maine and along its shores.

Some oil would likely be carried by tidal or wind-driven currents into the wetlands and estuaries along the New England Coast. If the oil had most of its volatile components (i.e., had not weathered), the effects on the wetlands could be quite serious, perhaps resembling the widespread damage reported in the marshes of West Falmouth, Massachusetts following a spill of light fuel oil (53). If the oil going into these wetlands had aged at sea, its effects on the marine life would be greatly reduced. Given sufficient time to weather at sea, the oil impact might well resemble that observed on the Cornish coast from the 1967 TORREY CANYON spill, i.e., pollution of many miles of shoreline. (without detergents effects) (51).

Owing to the intake of petroleum by shellfish and lobsters, it seems highly probable that the fishery for these organisms could be greatly damaged. The effect might be a complete loss of the shellfish and lobster catch for one or more years until the petroleum had decomposed, or been buried, and diluted sufficiently so that it no longer effected the organisms. In addition, if permanent tainting occurs, time will be needed to generate a population not so affected. The maximum loss would be approximately 20 million dollars per year (1969) with a processed value of about 48 million dollars. The data from the 1967 TORREY CANYON spill suggests that the effect on finfish would be less severe although there would likely be some tainting of fish and loss to fishermen owing to oil fouling their nets, boats and other equipment.

Depending on the season in which the spill occurred, losses to the coastal recreational industry could be quite large. For example, an entire tourist season might be lost with serious economic loss to coastal New England communities.

(b) Middle Atlantic Bight (Cape Cod to Cape Hatteras) (54). The Middle Atlantic Bight is the heavily urbanized part of the coastal ocean lying between Nantucket Shoals, south of Cape Cod, and Cape Hatteras, North Carolina. The warm subtropical waters of the Gulf Stream form the outer limits of this coastal circulation system. The so-called North wall of

the Gulf Stream is marked by a sharp change in water temperature between the cooler and less saline coastal ocean waters and the warmer saltier subtropical waters of the Gulf Stream. A broad zone of waters of intermediate temperature and salinity, called the Slope Waters, separate the Gulf Stream waters from the lower salinity waters which occur over the broad continental shelf.

The continental shelf is more than 100 miles wide southeast of New York City. The shelf narrows to the south and is only a few tens of miles wide offshore of Cape Hatteras.

Eastern Long Island Sound provides water deep enough for operation of the largest Title XI program tank vessels engaged in domestic trade. Most harbors in the region are too shallow for the largest vessels in the program without extensive dredging. "Handy Tankers" (35-40,000 DWT) could operate in most ports with relatively minor dredging required.

Except for Long Island Sound, massive spills of oil from the wreck of a tanker could occur only in coastal waters several miles from shore. Spills resulting from the loss of smaller tankers involving either crude or refined products could occur in Delaware Bay, in New York-New Jersey port area, in Chesapeake Bay, or in the harbors on Long Island Sound. Most other bays in the region are too shallow for tankers.

The general movement of the coastal waters of the Middle Atlantic Bight is westward south of Long Island and generally southerly along the New Jersey-Maryland-Virginia coastline. Current speeds are generally 5 to 10 miles per day. This general circulation appears to be driven primarily by the temperature-salinity distributions caused primarily by river discharge and fresh water mising with saline offshore waters.

Winds also have a major influence on the coastal circulation. Strong winds sustained for more than three days can locally reverse coastal currents. During the colder months of the year, the winds are generally from the west or northwest and move surface waters generally

offshore. During the warmer months, the winds are generally weaker but may also cause a shoreward movement of surface waters. In late summer when winds are generally weak and river discharge is low, the circulation of coastal waters becomes quite sluggish. At this time currents may be replaced by sluggishly moving large eddies near the shore.

Movements of subsurface waters are less well known. Studies of seabed drifter returns suggest that near-bottom waters near the coast move shoreward at speeds of a few tenths of a mile per day.

Water in the many small bays and lagoons as well as the larger estuarine systems including Long Island Sound, New York Harbor, Delaware Bay, and Chesapeake Bay exchange with the waters of the Middle Atlantic Bight. Tidal currents play the dominant role in the exchange of water through the inlets to the small bays and the entrances to the larger systems.

Winds play a dominant role in determining the movements of massive oil slicks in the coastal waters of the Middle Atlantic Bight. Analysis of smaller spills for the New York-New Jersey and Delaware Bay areas can also be used for general indications of the movements of more massive oil slicks will generally move seaward during the months of December through March and probably miss local beaches. During the remainder of the year, about 25 percent of the spills will probably reach the New Jersey beaches and areas to the south, about 25 percent will probably enter lower New York Harbor. The remaining half of the spills will affect the Long Island beaches and possibly enter Block Island Sound, Gardiners Bay and even eastern Long Island Sound. Some oil is likely to enter the smaller bays to be deposited on the wetlands and along the extensively developed suburban shorelines.

Despite the extensive organization and regional pollution problems, fish of the Middle Atlantic Bight are extensively exploited. The dominant species fished are surf clams, lobsters, oysters, menhaden and blue crabs. It is difficult to predict the effect of a massive spill on the commercial fishery and its exploitation. Oysters from Chesapeake Bay and New York waters are prone to tainting and possible loss of production owing to oil spills; although oysters themselves appear to be relatively

tolerant to crude oil as previously discussed. Hard clams, too, are likely to be affected by oil that enters the bays where they are produced along the Long Island and New Jersey coast. Surf clams and lobsters living on the continental shelf usually tens of miles from shore are less likely to be affected. Menhaden are not likely to be affected by spilled oil; although the slick from a spill may interfere with or even prevent fishing operations until it disperses or moves out of the region. In short, it is difficult to predict with precision the effect on local fisheries from a massive oil spill. But it seems likely that the loss to the Middle Atlantic fishery would well run into millions of dollars--perhaps tens of millions.

The Middle Atlantic coastal region is extensively urbanized. Major urban areas occur along the Connecticut coast, in the New York-Northeast New Jersey area, in the Philadelphia-New Jersey-Delaware area, at the head of Delaware Bay, and along the shores of Chesapeake Bay.

The shoreline is also extensively used for recreation. Southern Long Island and New Jersey beaches are especially heavily used owing to their proximity to large urban areas.

Seasonal housing is another major industry in the Middle Atlantic region. Many small communities on the barrier beaches (such as Fire Island) or on the bays contain large numbers of cottages occupied seasonally by the owners or rented for short-term occupancy by vacationers. Its importance is indicated by noting that waterfront lots on Long Island sell at prices ranging between $50 and $100 per foot of beach front. Considering the hundreds of miles of shoreline in the region, the value of such property would easily run in the billions. Even a small drop in value because of oil spills may represent a potential loss of many millions to the owners of such properties.

(c) Gulf of Mexico. The Gulf of Mexico has long been exposed to oil spills, some of them quite large, from oil well accidents, broken pipelines, barge and ship wrecks. Despite this frequent exposure to spilled oil, there are few reliable data available for evaluation of ecological

effects of individual spills and none in chronic or long term effects. Most of the available data discuss commercial species such as oysters, shrimp, and finfish. Future studies of the effects of well documented spills in the region would provide useful data for assessing the impacts on other U.S. coasts from oil spills of all sizes.

Owing to the shallowness of nearshore waters, a massive spill from a coastwise tanker along the Gulf Coast will most likely occur 2-3 miles offshore.

The effects to be expected from a massive spill will depend greatly on the time of year and the winds during and after the spill. In other words, if a spill occurs during the winter when winds are from the north, the oil may be blown offshore and have little or no impact on wetlands, beaches, or associated marine communities. Such oil could form globules in open ocean surface waters. If a summer spill occurs followed by winds from the south or southeast, the oil would be blown ashore and could well affect many miles of coast before the oil slick dissipated over a period of several weeks to a month.

Near the Mississippi Delta, the currents in the region will move the oil at an average speed of one knot toward the Louisiana and Texas coast if the spill occurs south and west of the Mississippi Delta. If, however, the spill occurs east of the Delta, the prevailing currents would generally move the slick southwesterly where it might not come ashore at all.

Biological effects are also strongly dependent on the season. If a spill occurred in the spring just before the growing and major reproductive season started, the effects would be greatest, especially if the oil were moved by winds and currents into the wetlands. At this time an oil spill could perhaps destroy the shrimp crop for that year in the areas affected, and it could also destroy new plant growth for that year in the wetlands. With no other spills, recovery could occur in one to two growing seasons if the local populations were not completely destroyed. Although resistant to toxic effects of crude petroleum, oysters may suffer mortalities due to clogging of feeding and respiratory organs. At the

very least, they would likely be tainted by the presence of oil and thus could not be sold commercially. Effects on adult fish are not well documented, but there may well be long term effects through damage to egg or larva stages, and the resulting possible destruction of an entire year class.

A massive spill that occurred in autumn after the major growing season would allow several months for the oil to decompose and to move through the permeable Marsh deposits where it would be out of reach for many organisms. Such a spill would have a minimal effect which might persist for only a single season.

(d) Southern California Bight (55). The Southern California Bight is an open embayment of the Pacific Coast. This area will be utilized as the possible terminus of the Alaskan crude oil trade. The United States portion of this urbanized coastal region extends from Point Conception on the north to the Mexican Border, just south of San Diego. This is a rapidly growing region and next to the Middle Atlantic Bight, Southern California is the most densely populated and extensively developed area of the U.S. coastline. The steeply sloping rocky coastline provides several areas where water depths are sufficient to permit operations of all the Title XI program tank vessels in domestic trade. Numerous submarine canyons also provide deep water access to port areas near the shore.

The southward flowing California Current lies offshore from the Southern California Bight. Unlike the Gulf Stream current, the California Current is highly responsive to the regional winds and the current speeds vary between 2 and 15 miles per day. Circulation of surface waters near the coast is complicated by the presence of the island offshore and the irregular bottom topography. For instance, the near shore circulation is generally south along the coast from Santa Monica to the Mexican Border but westward in the vicinity of Point Conception. North of Point Conception, the northward flowing Davidson Current is especially well developed in surface waters during the wetter months of the year owing to freshwater discharges and regional wind patterns. The flow of subsurface waters is

generally northward along the shore as part of the California undercurrent.

Superimposed on the above general circulation, the currents exhibit substantial variability. Regional winds are the dominant influence. Currents generally follow the winds. In the absence of strong winds, the regional currents will dominate at all depths on the shelf. Tidal currents also strongly influence the currents in the region. Because of this variability, it is difficult to predict with precision the movement of the slicks released from a massive oil spill that would accompany the wreck of a tanker. Much depends on the location of the accident, and the accident, and the winds at that time and during the lifetime of the surface slick.

In addition to the surface currents set up by the regional winds, there are vertical water movements that will tend to affect movements of oil slicks. Winds from the north or west that tend to parallel the coast move surface waters seaward. In this process, known as upwelling, surface waters and any floating oil are moved away from the coast and deeper waters are brought to the surface. These waters are cooler and the dissolved nutrients in them support the growth of the phytoplankton in the region. Upwelling seems to occur when the winds are in the proper direction and apparently ceases when the winds stop. These winds and associated upwelling will tend to keep the oil away from the coast.

Recreation is a major sector in the economy of the Southern California Region. It is estimated that about 85 million recreation-days are spent each year on the more than 100 miles of public beach in the South ern California coastal region. The value of such uses easily exceeds 100 million dollars each year. Other activities using the beaches include scuba diving in the shallow waters; more than 90 percent of such activities occur in waters less than 60 feet deep. Such recreational activities will be adversely affected by a massive oil spill in coastal waters.

The coastal waters are also heavily used for recreational boating. There are an estimated 350,000 small boats in the region. These boats

and the 14 marinas and boat harbors would require extensive cleanup following an oil spill.

Commercial fishing is apparently not a major factor in the economy of the region. Landings in the Los Angeles Region are now generally 20 to 40 million pounds per year compared to 100 to 150 million pounds in 1940 to 1945. Sardines, anchovy and various bottom fishes (halibut and rockfish) dominate the catches. Aside from the impact on recreational fishing, a massive oil spill would likely have little economic impact on the region's fishing industry.

(e) Puget Sound (60). As one of the few naturally confined deep water ports in the U.S., Puget Sound is likely to be used by the Alaskan oil trade engaged in domestic commerce, particularly by tankers exceeding 100,000 DWT.

If a tanker were grounded in Puget Sound and caused a large spill, the environmental impacts would be high for marine biota. The oil slick could spread to both sides of the Sound following the grounding of the vessel. The slick would be moved up and down the Sound by the strong tidal currents until the central part of the Sound would be exposed to the slick. Because of the complicated geometry of the system, much of the oil would likely wash into the sounds protected rocky coastline and beaches.

The turbulence of the waters and the relatively high particle concentrations would likely cause much of the oil slick to sink to the bottom. The results of these processes would probably be the removal of the slick from the surface within a few weeks. The complicated currents within the Sound might prevent floating oil from reaching all parts of the Sound. The wind regime following the spill would play a major role in determining where the oil would spread.

Extensive mixing of surface and subsurface waters at the spills in Puget Sound would likely result in emulsification of the oil to form oil-in-water emulsions. Tiny oil droplets would be widely dispersed through the water columns. Some of this oil would then tend to move with the sub-

surface waters and to penetrate into parts of the Sound not previously entered by the surface slick. In this way, the oil would likely be dispersed throughout the Sound and enter marine organisms far from the spill site.

The wetlands and shallow ocean bottom in the Sound would likely be covered with oil near the wreck. Depending on wind conditions, many small wetland areas and adjoining bays of the Sound would be severely damaged. Seabird mortality would be high and marine mammals (seals, whales) would be damaged.

If the shellfish and bottom fish were unusable for commercial purposes, this would represent a loss to Puget Sound fishermen of about $500,000 per year. If all commercial fishing were impossible, the loss would be about $2 million. Sport fishery (primarily for salmon) which is valued at about two million dollars annually would similarly suffer. Total value of the fishery to the Puget Sound region is estimated at about 40 million dollars (56).

In the cold waters of Puget Sound, a massive oil spill would likely take much longer to dissipate than in the Gulf Coast area.

Oil from a wreck in Puget Sound might enter the Strait of Juan de Fuca and potentially the Strait of Georgia system as well. It seems unlikely that large quantities of floating oil would escape from Puget Sound to flow into the coastal currents of the Pacific Ocean.

(f) Inland Waterway Oil Spill Impact. Perhaps the best way to describe the impact of a major oil spill on an island waterway is to summarize the effects from an actual spill. A recent and notable inland waterway oil spill is the international pollution incident on June 23, 1976 resulting from the grounding of the NEPCO 140 tank barge in the vicinity of Alexandria Bay on the St. Lawrence River. Three of the barges cargo tanks were punctured, spilling about 7,355 barrels of No. 6 fuel oil (57).

River currents in the main channel ranged from 3 to 5 ft/sec., making it impossible to control the movement of oil by conventional containment measures. Cleanup crews had to wait until the oil moved into protected and semi-enclosed areas such as shore line coves and the leeward side of islands where containment could take place. The spilled oil moved rapidly downstream at a speed of 2-1/2 miles per hour, a distance of 75 miles within 30 hours. The wildlife areas in Chippewa and Goose Bays received the worst impact. Alexandria Bay Harbor, a focal point in New York State's Thousand Island tourism trade was most vulnerable to economic loss; consequently, clean up activity in this area received the highest priority and restoration was completed before the 4th of July weekend holiday.

The Canadian side of the river was fortunate in that the impact on wildlife areas was minimal. Most of the oil concentrated along the American side of the river and as much as 80% area coverage was observed for a distance of 55 miles from the leaking barge. The mixing energy from the powerhouse and flood control dams at Cornwall mitigated the impact by dispersing the oil to a low concentration.

The containment and clean up operations employed several out of state private contractors. Conventional oil barriers were ineffective in high currents, but booms deployed near the shore prevented contamination of important wildlife areas. The clean up equipment ranged from mechanical devices such as skimmers, vacuum trucks and steam sprayers to manual devices such as shovels, rakes and pitchforks. The shoreline was cleaned by employing high pressure hoses to remove residual oil from rock and dock areas. Accumulated oil from the cleaning was recovered by the use of a synthetic sorbent material. Marshes were cleaned manually by the use of sickles and scythes to cut reeds below the contaminated area for removal by boat.

A bird cleaning station was organized by the New York State Department of Environmental Conservation where a large number of rounded up birds were taken to remove heavy oil. Of the sixty-seven oil contaminated birds treated, only seven of them were badly contaminated and three birds died from exposure.

The size of the spill was relatively small, however, because the incident occurred in an extremely sensitive and vulnerable location, the cost of clean up operations amounted to $8.5 million.

Specifically, the exorbitant expense was attributed to:

- difficult access to contaminated areas
- large number of sites (thousands) where recontamination occurred
- effects on St. Lawrence river recreation
- effect on wildlife reserves

C. CHEMICAL POLLUTION (58)

1. GENERAL

During the past decade there has been a rapid growth in the waterborne transportation of bulk liquid chemicals within U.S. coastal waters by tanker and tank barges. In comparison to the net petroleum commerce, the total tonnage is small; however, the growth of chemical and hazardous material transport and the danger of some of the cargoes requires that this segment of the marine industry be heavily regulated. (See Chapter V for more details on regulations).

This section will discuss the chemical and hazardous liquid pollution from tankers and tank barges and indicate to the extent possible the fate and effect of the pollutant.

Chemical pollution of the U.S. waters is very small in comparison to the volume of oil pollution simply because the total tonnage shipped is not as large as oil shipments. Table IV-15 illustrates this comparison of the number of incidents and volume discharge of oil with incidents involving other substances in U.S. waters during calendar year 1976. The volume outflow of liquid chemicals during that year amounted to only 6.2 percent of the total outflow and the corresponding number of incidents was only 2.3 percent of the total.

Table IV–15
TYPE OF POLLUTION
OIL AND OTHER SUBSTANCES

SUBSTANCE	NUMBER OF INCIDENTS	% OF TOTAL	VOLUME IN GALLONS	% OF TOTAL
OIL				
CRUDE OIL	2,667	21.1	4,990,691	14.7
FUEL OIL	909	7.2	9,780,886	28.9
GASOLINE	658	5.2	764,168	2.3
OTHER DISTILLATE FUEL OIL	251	2.0	462,140	1.4
SOLVENT	34	0.3	95,317	0.3
DIESEL OIL	2,063	16.3	1,100,133	3.2
ASPHALT OR RESIDUAL FUEL OIL	132	1.0	4,982,195	14.7
ANIMAL OR VEGETABLE OIL	93	0.7	94,513	0.3
WASTE OIL	1,217	9.6	131,377	0.4
OTHER OIL	2,636	20.8	724,294	2.1
OTHER SUBSTANCES				
LIQUID CHEMICAL	296	2.3	2,110,048	6.2
OTHER POLLUTANT (Sewage, dredge, spoil, chemical wastes, etc.)	130	1.0	6,468,940	19.1
NATURAL SUBSTANCE	94	0.7	6,468	0.0
OTHER MATERIAL	146	1.2	2,120,386	6.3
UNKNOWN MATERIAL	1,329	10.5	20,274	0.1
TOTAL	12,655	100.0	33,851,830	100.0

SOURCE: Pollution Incidents In and Around U.S. Waters, Pollution Incident Reporting System, Calendar Year 1976, U.S. Coast Guard, Washington, D.C.

It is difficult to estimate exactly what amounts of this chemical pollution is attributed to tankers and tank barges. It is even more difficult to determine what percentage of this pollution is a result of Title XI program tank vessels engaged in domestic trade. It can be surmised from the statistical data in Table IV-15, that the chemical pollution from tank vessels is very small in comparison to the other materials being discharged to U.S. waters; (i.e., oil).

2. CHEMICAL TANKERS

Chemical tankers present several potential sources of pollution to the marine environment through normal ship operation. The cause of chemical pollution, i.e. casualties of operational practices, would be expected to be similar to those for oil tankers.

Chemical tankers can also cause oil pollution since oil can be carried as a cargo on many of these ships. Most chemical carriers are designed to carry multiple products, chemicals and petroleum products included. Pollution can also occur during pumping of engine room bilges and bunkering operations. A discussion of these causes of pollution will not be repeated here because they are basically the same as those in the section on tankers (See Section IVB).

The two major sources of operational pollution from shipping chemicals are: (1) ballasting and tank cleaning operations and (2) terminal operations.

a. OPERATIONAL POLLUTION (BALLASTING AND TANK CLEANING)

After having discharged the cargo, a chemical tanker must ballast with sufficient water to insure proper propeller immersion and to maintain ship controllability and seakeeping characteristics. The amount of ballast taken aboard depends upon the anticipated weather conditions, the distance and route of the ballast voyage, and the vessel's characteristics. The amount of ballast generally varies from 20 to 40 percent of the vessel's full load displacement, but may be greater during periods of adverse weather.

The ballast that is loaded into cargo tanks after cargo discharge comes into contact and "mixes" with the chemicals that have adhered to the tank surfaces or remained in the cargo suction piping system. Depending on the location of the vessel, this contaminated ballast may be treated to remove the contaminants and disposed of by discharge to the sea or discharged to a reception facility upon arrival at the loading port. Pollution control regulations concerning these discharges are discussed in Section V.

In general, chemical tankers are designed with varying amounts of segregated ballast tanks. As much dedicated ballast as possible is included in the design of chemical ships, and this becomes more important as the proportion of chemicals to other cargoes increases on the ship.

Excess volume is common in modern chemical tankers and can provide some dedicated ballast space. Cofferdams and innerbottom tanks, where present, also can be utilized.

Liquid substances other than oil discharged worldwide into the sea during normal tank cleaning operations during 1970 were estimated to be slightly less than 10,000 tons (59).

The load-on-top method of retaining tank cleaning wastes, commonly used in the oil tanker trade, cannot be generally used on chemical tankers. The prime reason is the number of different cargoes carried per voyage and the possible adverse effects of mixing these different types of chemicals (i.e., dangerous chemical reaction and delivery of a poor quality product). The tank washing discharge of IMCO Grade A cargoes will be prohibited by IMCO rules (60) and must be pumped to shore facilities. IMCO Grades B, C and D cargoes may be discharged overboard but under controlled conditions (See Section V for details). It should be noted that to completely clean a tank as much cargo as possible is pumped out by means of portable eductor.

In a discussion of operational discharges, some note must be made of the cost of the cargoes and the importance of cargo purity. In the past when environmental considerations were not stressed, the design of the

ships for cleanliness and the amount of effort spent in stripping the cargo before washing was dependent upon cargo worth. For instance, with relatively low cost crude oil cargoes, the time and equipment needed to completely strip the tanks cost more than the lost cargo was worth. The resultant pollution of the seas from such operational discharges has been a main source of environmental damage from bulk liquid shipping. On the other hand, a few of the modern chemical tankers have double hulls, double bottoms and drain wells with special stripping pumps in each hold. Such systems are said to leave less than one gallon of cargo in the tank excluding clingage.

b. TRANSFER OPERATIONS

Accurate figures on the amount of chemicals spilled during loading and unloading operations are not known. In Table IV-7, the estimated oil spillage rate from terminal operations is 400 metric tons per year for domestic vessels which is equivalent to 125,000 gallons per year (assuming a specific gravity of .85 for oil). This estimated value of oil spillage rate is much smaller than the actual value of 274,677gallons reported for calendar year 1976. It should be recognized that errors occur both in estimating spill rates as well as in reporting actual spill sizes. Using the 1976 data, chemical spill volume from terminal operations is about one-fifth the value of the oil spill volume from the same source. While this annual spill rate is small, it is possible that a spill of larger magnitude can occur occasionally causing an adverse effect on marine life in the spill area. Also, it should be kept in mind that a chemical spill may be more lethal or damaging than an equivalent quantity of oil.

As with oil tanker operations, there are three principal reasons for chemical pollution at marine terminals: (1) mechanical faults: (2) design faults; and (3) human error. It is expected, however, that spillage incidents of chemicals during transfer operations are much less frequent than experienced during oil operations. This is due to the low rates of cargo transfer used in the chemical trade, the need for cargo purity, and extensive safety precautions because of the hazardous nature of some of the chemicals.

c. CHEMICAL TANKER ACCIDENTS

The effects of the spillage of chemicals into the sea will vary greatly, depending upon the chemicals in question, and may or may not result in consequences more serious than those resulting from the casualty discharge of a petroleum product. Not only must the hazard of the discharged chemical itself be considered, but the compatibility of the chemicals discharged, both between themselves and the environment (i.e., air and water), must be taken into account. Ships designed for the carriage of the cargoes considered most dangerous to the environment are constructed with double bottoms and wing tanks outboard of the cargo spaces, which reduces the chance of leakage. The requirements for ship construction are less restrictive for other less dangerous cargoes.

Cargo containment and arrangement aboard tank vessels have been considered in the efforts to limit or prevent accidents and their consequences. The IMCO Code for Bulk Chemical Carriers provides for three ship types, each type being governed by the type of cargo to be carried and the relative cargo hazard. The three ship types provide three different degrees of physical cargo protection by defining the location of the cargo space within the hull, the volume of the cargo space, and the extent to which the ship should be capable of remaining afloat after damage. Noxious substances other than oil have also been divided into four broad categories by IMCO, based upon their potential hazard when considering their effects on living resources, human life and health, and interference with the use of the seas. (See Section V D for details regarding IMCO requirements).

There is no data available at present indicating the amount of chemicals discharged into the sea as a result of vessel accidents. In light of the differences in vessel construction, the accident data used for oil tankers is not applicable to chemical tankers. Because chemical tankers are of generally safer construction (e.g., double bottoms and double hulls) and smaller size (world fleet average of less than 2,000 DWT/ship), the total loss of cargo and the probability of cargo loss by casualty would be much less than expected with a similar number of oil tankers.

The types of accidents experienced by chemical tankers are the same as those encountered by oil tankers. Collisions and groundings, as with oil tankers, very likely represent 50 percent of the total number of casualties that occur (5). Groundings and collisions result from poor navigational aids, uncharted rocks and/or reefs, bad weather, poor operational practices, and errors on the part of ship crews and/or pilots. The remaining types of casualties tend to result from improper operations, inadequate design, and human error.

It is apparent from the above that the consequences of a spill from a chemical tanker accident depend upon the chemical or combination of chemicals spilled and the design and equipment of the ship. The segregation of chemical cargoes and the use of wing tanks and double bottom tanks should, however, minimize damage to, and thus the release of cargo from the vessel's tanks.

The wide variety of chemical types being transported in bulk by tankers increases the types of impacts on the environment which must be dealt with after an accidental spill occurs. Some chemicals are very volatile, others will float on the surface of the sea, some will sink, some will mix and disperse, and some will react with either the water or the air. The effects that each chemical will have on the environment should be analyzed separately in light of the unique hazards it represents.

3. CHEMICAL TANK BARGES (61)

As with oil carrying tank barges, the primary causes of chemical pollution are: (1) discharges due to leaks, (2) spills during loading and unloading, and (3) barge accidents. The first two will not be addressed because of their similarity to spills in oil tank barges, discussed previously. A discussion of chemical tank barge accidents is provided on the following page.

a. CHEMICAL TANK BARGE ACCIDENTS

A Marad study entitled "A Modal Economic and Safety Analysis of the Transportation of Hazardous Substances in Bulk" examined, among other things, accidents involving barges carrying hazardous materials (61). As part of this study, a locational listing of barge accidents involving pollution as shown in Table IV-16 was developed for the time period July 1968 - June 1973. Each accident included in the study appears as a result of a vessel casualty reported to the Coast Guard and does not necessarily represent the total population of such type pollutions. As defined by 46 CFR 136, a reportable marine casualty results from any of the following: (a) Actual physical damage to property in excess of $1500; (b) Material damage affecting the seaworthiness or efficiency of a vessel; (c) Stranding or grounding; (d) Loss of life; and (e) Injury causing any person to remain incapacitated for a period in excess of 72 hours, except injury to harbor workers not resulting in death and not resulting from vessel casualty or vessel equipment casualty.

As illustrated in Table IV-16 of the 96 accidents involving 174 barges, almost half of these occurred on the Mississippi River, with the remainder equally divided between the Gulf Intracoastal Canal and other rivers. However, the number of barges involved in accidents is quite different for the three areas. The ratio of barges to accidents for the Mississippi was 2.1 (i.e., 93 divided by 44), 1.8 for the Gulf Intracoastal Canal, and 1.3 for the other rivers of interest. These ratios reflect the possible different traffic densities in the various areas. Also shown are the annual barge accident rates for certain segments of the inland waterways (i.e., the number of barges involved in accidents divided by 5 years).

4. FATE OF CHEMICAL SPILLS

a. OVERVIEW

A spilled chemical, depending on its own particular physical and chemical characteristics, can undergo many transformations upon release into the marine estuarine and aquatic environments.

Table IV–16
CHEMICAL TANK BARGE ACCIDENTS INVOLVING POLLUTION
JULY 1968 – JUNE 1973*

LOCATION		NUMBER OF ACCIDENTS	NUMBER OF BARGES INVOLVED IN ACCIDENTS	ANNUAL BARGE ACCIDENT RATE
SEGMENTS OF THE MISSISSIPPI				
MINNEAPOLIS –	MOUTH OF MISSOURI	11	18	3.6
MOUTH OF MISSOURI –	MOUTH OF OHIO	6	16	3.2
MOUTH OF OHIO –	BATON ROUGE	11	31	6.2
BATON ROUGE –	NEW ORLEANS	7	13	2.6
NEW ORLEANS –	MOUTH OF PASSES	9	15	3.0
	TOTAL	44	93	18.6
SEGMENTS OF GULF INTRACOASTAL CANAL				
MISSISSIPPI –	SABINE RIVER	13	21	4.2
SABINE RIVER –	GALVESTON	6	12	2.4
GALVESTON –	CORPUS CHRISTI	6	12	2.4
PENSACOLA –	MOBILE	1	1	0.2
MOBILE –	NEW ORLEANS	2	3	0.6
	TOTAL	28	49	9.8
OTHER AREAS OF INTEREST				
OHIO RIVER		15	22	4.4
TENNESSEE RIVER		4	4	0.8
NECHES RIVER		1	2	0.4
KANAHWA RIVER		1	1	0.2
ILLINOIS RIVER		2	2	0.4
COLUMBIA RIVER		1	1	0.2
CHICAGO RIVER		0	0	0.0
	TOTAL	24	32	6.4
	GRAND TOTAL	96	174	34.8

* INCLUDES TANK BARGES (INFLAMMABLE AND COMBUSTIBLE CARGOES), CARGO BARGES (DANGEROUS AND HAZARDOUS CARGOES) AND TANK BARGES (DANGEROUS AND HAZARD–OUS CARGOES).

SOURCE: A Modal Economic and Safety Analysis of the Transportation of Hazardous Substances in Bulk, Maritime Administration, prepared by Arthur D. Little, Inc., July 1974.

A computer simulation ("vulnerability model") designed to provide quantitative measures of the consequences of hazardous materials spills prepared for the U.S. Coast Guard considers five spill scenarios for a spilled liquid (62). They are:

- "Spreading and evaporation of an immiscible, floating cryogenic liquid"
- "Spreading and evaporation of an immiscible, floating liquid with high vapor pressure
- "Sinking and boiling of an immiscible liquid"
- "Mixing, advection, and dilution of a miscible liquid in a tidal river, nontidal river or still water"
- "Mixing, dilution, and evaporation of a miscible liquid with high vapor pressure"

There are other possibilities, but those considered encompass the largest number of cargoes frequently transported by tankers and tank barges. Liquefied natural gas, for example, is treated by the first scenario, gasoline by the second, and liquid chlorine by the third. The simulation operation is divided into two phases. Phase I simulates the spill itself, and the physical and chemical transformations and dispersions of the spilled substance. Phase II models the effects of toxicity, explosion, and/or fire on the vulnerable resources as a function of time and estimates the number of deaths and nonlethal personal injuries. A generalized flow diagram of the simulation model is presented in Figure IV-8.

The processes which influence the distribution and fate of a miscible chemical liquid is shown in Figure IV-9. The starting point of these processes would be the end point of Phase II of the vulnerability model flow diagram in Figure IV-8 .

b. PHYSICAL DILUTION AND DISPERSION

The most significant physical influence on distritution of pollutant in the aquatic environment results from water movements. Motions

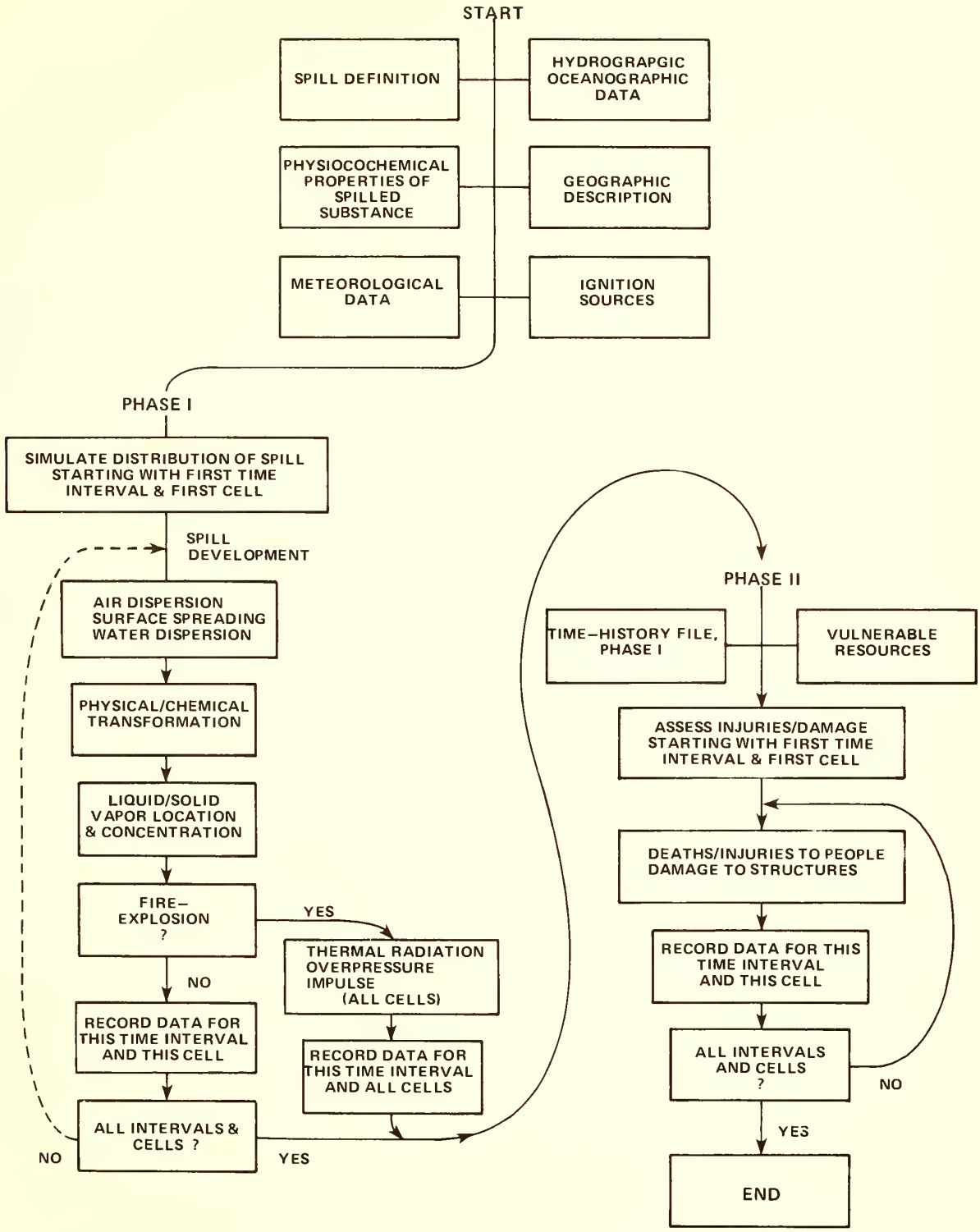


Figure IV–8 GENERALIZED FLOW DIAGRAM OF THE VULNERABILITY MODEL

SOURCE: Vulnerability Model: A Simulation System for Assessing Damage Resulting from Marine Spills, U.S. Coast Guard, Washington, D.C., June 1975

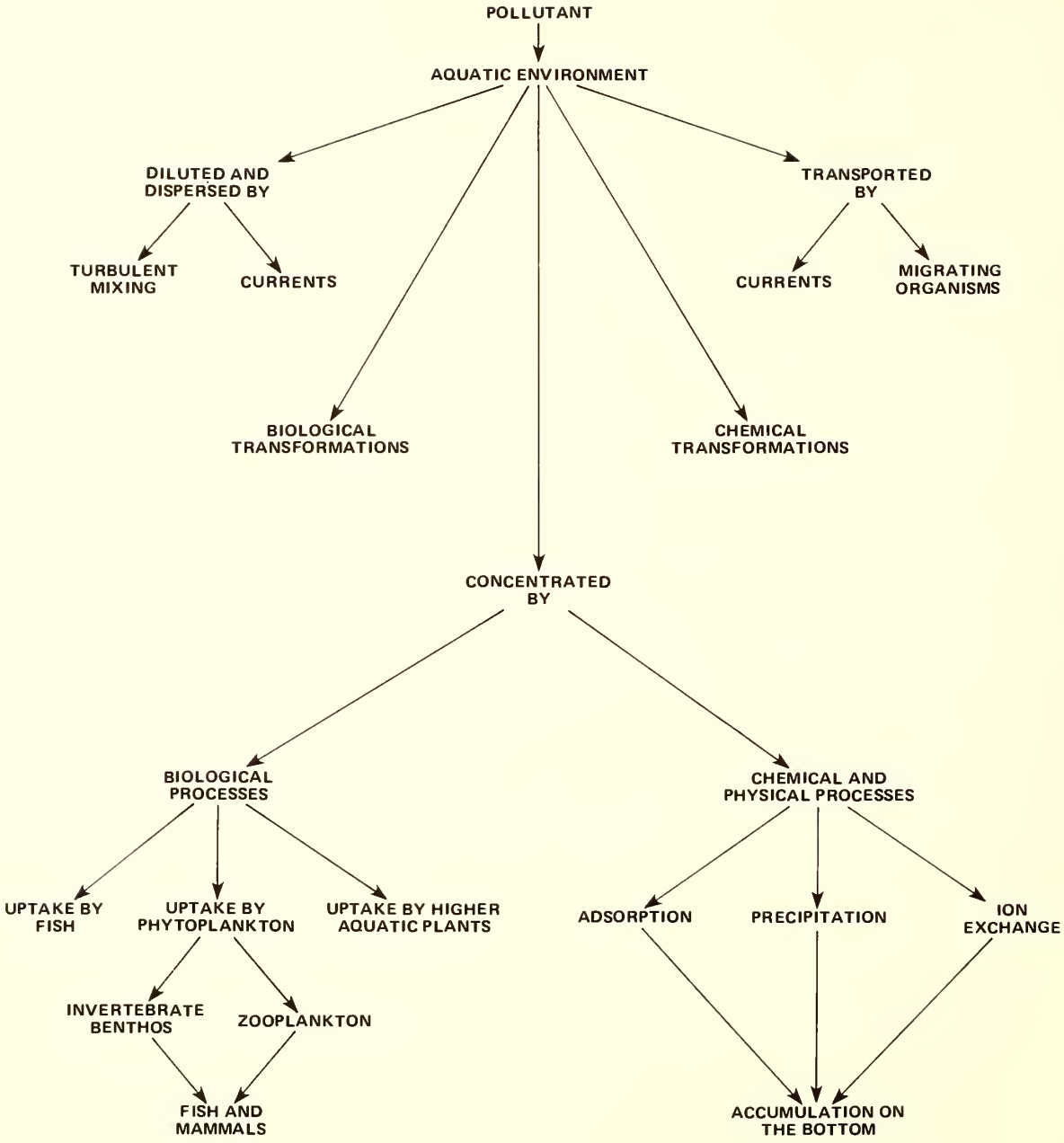


Figure IV–9 PROCESSES WHICH INFLUENCE THE DISTRIBUTION AND FATE OF POLLUTANTS ENTERING THE AQUATIC ENVIRONMENT

SOURCE: Dawson, G.W. et. al., 1970, Control of Spillage of Hazardous Polluting Substances, Battelle Memorial Institute, Pacific Northwest Laboratories.

are common in both the sea and freshwater, ranging from those of molecular dimensions to river and oceanwide current systems (63). Wind is the most effective source of energy in dispersing chemicals since it results in turbulence and wind waves, the latter of which exhibit subsurface orbital motions. These motions have a considerable influence in mixing and dispersion. Tidal currents are particularly important to dispersion in coastal waters, since they occur on a rhythmic daily basis. The influences of ocean currents, such as the California Current, and of inflowing freshwater rivers are also important.

Soluble substances will sooner or later be completely dissolved although the process is accelerated in the presence of water movement. Neutrally buoyant and soluble substances may remain in the water column indefinitely and be removed by the processes indicated in Figure IV-9. Temperature and salinity influence rates of solubility and precipitation of soluble pollutants, as well as the coagulation of dispersed material.

Insoluble substances with lower density, such as mineral oil, will float on the surface and be deposited on shore from which they are later removed by waves, surf, or currents. If the substance is heavier than sea water, it will sink with a velocity depending on its density, shape, and size. Viscosity, which depends upon temperature and salinity, will have an indirect influence by determining the sinking velocity of particles (62).

c. CHEMICAL TRANSFORMATIONS

Substances are affected in the aquatic environment by chemical transformations of either an inorganic or biological nature. Inorganic chemical transformations include radionuclide decay, oxidation-reduction, and hydrolysis. If solution parameters are known, these reactions can be predicted with reasonable certainty.

Biological reactions, including biochemical and microbial transformations, are considerably more complex. Biochemical degradation mechan-

isms include: dehalogenation, dealkylation, amide and ester hydrolysis, oxidation-reduction, ether fission, aromatic ring hydroxylation, and ring cleavage.

The rate, extent, and direction of microbial transformations of chemicals are commonly dependent upon the predominant flora and fauna, energy sources, available nutrients, degree of aeroation, temperature, moisture, pH, light, and the presence of toxic substances. Recent studies by Jannasch and Einhjellen (64) have demonstrated that low rates of microbial activity exist under deep sea conditions. These authors concluded that deep sea waste disposal would be extremely inefficient and involve the transport of waste products of intermediate decomposition products by bottom currents.

d. CONCENTRATION IN THE ECOSYSTEM

Aquatic organisms may biologically concentrate materials introduced into the aquatic environment. Buildups are achieved as uptake proceeds through the food chain from phytoplankton through fish and mammals (65). Although a relative paucity of data exists in the area of biological concentration for most pollutants, the process is termed bioaccumulation (66) and is considered to occur if an organism takes up a chemical to which it is exposed so that it contains a higher concentration of that substance than is present in the ambient water or its food. The process is reversible and bioaccumulation may be short lived. Less than 24 metabolites may be formed from ingested substances which may be more poisonous or ecologically damaging and/or have a longer biological half life than the original material.

Pollutants are also concentrated in bottom materials, as for example when they adhere to particles of clay or other suspended material and are carried to the bottom sediments (67). They are also occasionally concentrated in other non-living nitches as in the case of DDT in surface films of oil on the sea.

e. ENVIRONMENTAL VARIABLES

An assessment of the hazards of bulk chemical carriage upon the aquatic environment includes the following basic sets of variables:

(1) Variability of Environmental Condition. In the event of a chemical spill, the extent of chemical dispersion will be determined by a multitude of natural, physical, and chemical conditions, including pollution loads, water chemistry, etc. For example, the environmental impact of the loss in an estuary of a toxic chemical which is slightly soluble, but heavier than water, will be substantially determined by the conditions of wave action and/or tidal and wind induced currents. Without current or wave action, its heavier specific gravity would carry the chemical directly to the bottom where toxic effects will be imposed on the benthos. On the other hand, with wave action and/or current, the same chemical would be diluted and transported from the immediate spill site. Thus bottom dwelling organisms or benthos at the immediate site would be spared toxic impacts, although the same may not be said for down current organisms.

(2). Variability of Biotic Resources. The initial impact of a toxic chemical spill is limited to a large extent by the kinds, life stage, and abundance of flora and fauna present at the time and place of the spill. Subsequent impacts of the spill will similarly be limited by the kinds and abundance of organisms passing through or exposed to the chemical during its period of dissipation, dilution, dissolution, or decomposition. The distribution of biota is not random, and species generally inhabit very specific nitches within the ecosystem, e.g. clams in the tidal zone. Thus, a toxic chemical spill in a productive biological area will have greater biological impacts than one in a less productive zone.

(3) Variability Of Spill Volumes. The net impacts of a toxic chemical spill will be determined to a great extent by the volume of chemical lost. Large losses provide the potential for extensive pollution effects; whereas, smaller losses normally have proportionately smaller impacts.

(4). Varying Chemical Characteristics. Chemicals vary greatly in their physical and chemical characteristics and mechanisms of dispersion and toxicity. Some chemicals are not soluble in water and, thus, are not readily subject to dilution. Specific gravity and solubility are important in determining whether a spilled chemical remains in the surface water layer, reaches lower water layers or the bottom, or is mixed throughout the water column.

f. ENVIRONMENTAL HAZARD IDENTIFICATION AND EVALUATION SYSTEMS

The process of examining and judging a material or event as a source of danger can be defined as hazard identification and evaluation (68). The rapid expansion of the chemical industry, combined with major advances in shipping technology, has created a wide spectrum of problems in assigning suitable hazard ratings to specific chemical cargoes.

Several hazard identification and evaluation systems have been developed. These include systems by: (a) the Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) (66); (b) the Intergovernmental Maritime Consultative Organization (IMCO) (60); (c) the U.S. Coast Guard (69); and (d) the Environmental Protection Agency (70).

(1). Joint Group of Experts on the Scientific Aspects of Maritime Pollution (GESAMP) (66,71). In November 1971 the Intergovernmental Maritime Consultative Organization (IMCO) convened an International Convention for the Prevention of Pollution from Ships at which time the group requested GESAMP to review the noxious liquid substances carried in bulk and to consider their hazard to the environment. In developing hazard profiles for the selected substances, GESAMP used the following criteria:

Bioaccumulation. Bioaccumulation occurs if an aquatic organism takes up a chemical to which it is exposed so that it contains a higher concentration of that substance than is present in the ambient water or its food. Profile ratings are:

> bioaccumulated and liable to produce a hazard to aquatic life or human health,

- not known to be significantly bioaccumulated,
- short retention of the order of one week or less,
- liable to produce tainting of seafood.

Damage to Living Resources. In calculating damage to living resources, available 96 hour TLm (tolerance limit median) data is used. TLm is defined as the concentration of a substance which will, within the specified time, kill 50% of the exposed group of test organisms, often specified in parts per million. The bioassay may be conducted under static or continuous flow conditions. Profile ratings used:

- highly toxic,
- moderately toxic,
- slightly toxic,
- practically non-toxic,
- non-hazardous,
- problem caused primarily by high oxygen demand,
- deposits liable to blanket the seafloor.

Damage to Human Health. Three principal ways were considered in which injury to human health can occur from a substance polluting the seas and waterways, namely through ingestion of water containing the substance, ingestion of fish and shellfish which have accumulated the substance, and direct human contact with the substance and its vapors. The degrees of hazard are listed in terms of the median lethal dose (LD_{50}) of the substance, i.e., the dose of substance which will, within a specified period to time, kill 50% of a group of test animals to which it is administered. Profile ratings are:

- hazardous (solution).
- slightly hazardous (solution),
- non-hazardous (solution).

Reduction of Amenities. Amenities are defined as values of the recreational use or scenic aspects of the environment. Profile ratings are:

- highly objectionable because of persistency, smell, or poison-

ous or irritant characteristics - beaches liable to be closed;

- moderately objectionable because of the above characteristics, but short-term effects leading to temporary interference with use of beaches;
- slightly objectionable, no interference with use of beaches;
- no problem

In addition to hazard profiles of selected substances the levels of dangerous toxic discharges which would be expected to kill aquatic life were estimated. These estimates are presented in Table IV-17. GESAMP recommended extreme caution in using these data, however, to insure that the results are not extrapolated to systems substantially different than those described.

(2). Intergovernmental Maritime Consultative Organization (IMCO)(60,71). The 1973 IMCO International Convention for the Prevention of Pollution from Ships in Annex II dealt with pollution by noxious liquid substances transported in bulk other than oil, sewage and garbage (60). The substances to which Annex II of the convention applies have been subdivided into the following categories based on the hazard ratings assigned by GESAMP.

Category A. Substances which are bioaccumulated and liable to produce a hazard to aquatic life or human health or highly toxic to aquatic life (as expressed by a Hazard Rating 4, defined by a TLm less than 1 ppm); and additionally certain substances which are moderately toxic to aquatic life (as expressed by a Hazard Rating 3, defined by a TLm of 1 ppm or more, but less than 10 ppm) when particular weight is given to special characteristics of the substance.

Category B. Substances which are bioaccumulated with a short retention of the order of one week or less; or which are liable to produce tainting of the sea food; or which are moderately toxic to aquatic life (as expressed by a Hazard Rating 3, defined by a TLm of 1 ppm or more, but less than 10 ppm); and additionally certain substances which are slightly toxic to aquatic life (as expressed by a Hazard Rating 2, defined by a TLm of 10 ppm or more, but less than 100 ppm) when particular weight is

Table IV–17
TOXIC DISCHARGE LEVELS WHICH WOULD BE EXPECTED TO KILL MOST AQUATIC LIFE IN SPECIFIED SYSTEMS

TOXICITY RANGES (TLm) ppm	RIVERS* (1000 cfs)	ESTUARY*	SHALLOW COASTAL WATERS*
100 – 1000	6.6 – 66 TONS	62.5 – 625 TONS	5000 – 50000 TONS
10 – 100	1320 – 13200 LBS	6.25 – 62.5 TONS	500 – 5000 TONS
1 – 10	132 – 1320 LBS	0.62 – 6.25 TONS	50 – 500 TONS
0.1 – 1.0	13 – 132 LBS	125 – 1250 LBS	5 – 50 TONS
0.01 – 0.1	1.3 – 13 LBS	12.5 – 125 LBS	0.5 – 5 TONS
< 0.01	< 1.3 LBS	< 12.5 LBS	< 0.5 TONS

* SEE EXAMPLES 1, 2, AND 3 IN ANNEX V OF THE GESAMP REPORT (REFERENCE 70) FOR ASSUMED SYSTEM AND MATERIAL CHARACTERISTICS AND METRIC EQUIVALENTS.

SOURCE: GESAMP IV/19 Supplement 1, March 19, 1973.

given to additional factors in the hazard profile or to special characteristics of the substance.

Category C. Substances which are slightly otxic to aquatic life (as expressed by a Hazard Rating 2, defined by a TLm of 10 or more, but less than 100 ppm); and additionally certain substances which are practically non-toxic to aquatic life (as expressed by a Hazard Rating 1, defined by a TLm of 100 ppm or more, but less than 1,000 ppm) when particular weight is given to additional factors in the hazard profile or to special characteristics of the substance.

Category D. Substances which are practically non-toxic to aquatic life, (as expressed by a hazard rating 1, defined by a TLm of 100 ppm or more: but less than 1,000 ppm); or causing deposits blanketing the seafloor with a high biochemical oxygen demand (BOD); or highly hazardous to human health, with an LD_{50} of less than 5 mg/kg; or produce moderate reduction of amenities because of persistency, smell or poisonous or irritant characteristics possibly interfering with use of beaches; or moderately hazardous to human health with an LD_{50} of 5 mg/kg or more, but less than 50 mg/kg and produce slight reduction of amenities.

Other Liquid Substances. Substances other than those Categories A,B,C, and D above.

Representative chemicals and their respective pollution categories are given in Table IV-18.

(3). U.S. Coast Guard (69). The National Research Council's Committee on Hazardous Materials assisted the U.S. Coast Guard in developing a hazard evaluation system for bulk dangerous cargoes and assigning suitable ratings. The results of the Committee's Study are summarized in the report, "Evaluation of the Hazard of Bulk Water Transportation of Industrial Chemicals - A Tentative Guide", published in 1966 and revised in 1969, 1970 and 1972. The ratings represented the overall hazard potential connected with the bulk waterborne shipment of specified industrial chemicals.

Table IV–18
A SAMPLE OF NOXIOUS LIQUID SUBSTANCES
CARRIED IN BULK

SUBSTANCE	UN NUMBER	POLLUTION CATEGORY FOR OPERATIONAL DISCHARGE	RESIDUAL CONCENTRATION (PERCENT BY WEIGHT)	
		(REGULATION 3 OF ANNEX II)	(REGULATION 5(1) OF ANNEX II)	(REGULATION 5(7)OF ANNEX II)
	I	II	III OUTSIDE SPECIAL AREAS	IV WITHIN SPECIAL AREAS
–ACETALDEHYDE	1089	C		
–ACETIC ACID	1842	C		
–ACETIC ANHYDRIDE	1715	C		
–ACETONE	1090	D		
–ACETONE CYANOHYDRIN	1541	A	0.1	0.05
–ACETYL CHLORIDE	1717	C		
–ACROLEIN	1092	A	0.1	0.05
–ACRYLIC ACID*	–	C		
–ACRYLONITRILE	1093	B		
–ADIPONITRILE	–	D		
–ALKYLBENZENE SULFONATE				
(STRAIGHT CHAIN)		C		
(BRANCHED CHAIN)		B		
–ALLYL ALCOHOL	1098	B		
–ALLYL CHLORIDE	1100	C		
–ALUM (15% SOLUTION)	–	D		
–AMINOETHYL–ETHANOLAMINE				
(HYDROXYETHYL–ETHYLENEDIAMINE)*	–	D		
. . . . .				
ETC.				

* INDICATES THAT THE SUBSTANCE HAS BEEN PROVISIONALLY INCLUDED IN THIS LIST AND THAT FURTHER DATA ARE NECESSARY IN ORDER TO COMPLETE THE EVALUATION OF ITS ENVIRONMENTAL HAZARDS, PARTICULARLY IN RELATION TO LIVING RESOURCES.

SOURCE: 1973, Imco Marine Pollution Convention, Annex II – Appendix II of Ref.60.

The hazard evaluation is based on four main classes of hazards: fire, health, water pollution, and reactivity. A brief description of the hazards follows, including a general scheme of the system as shown in Table IV-19. The specific National Academy of Sciences (NAS) hazard ratings of a representative sample of chemicals transported under various transport conditions is given in Table IV-20.

Fire Hazards. Chemicals are classified as having a fire hazard if properties are such that they may ignite or may spread a fire during bulk water transportation. Ratings are based principally on flash points; however, other factors may be considered and the rating raised or lowered accordingly if the chemical represents a hazard unlike the hazard of hydrocarbons. Chemicals having such unique hazards include: (1) chemicals such as halogen-, nitrogen-, or sulfur - containing compounds that evolve noxious gases in burning; (2) chemicals having exceptionally high or low ignition temperatures; and (3) chemicals that ignite spontaneously on contact with air or water.

Health Hazards. Health hazards are classified as originating from (1) gases, vapors, fogs and mists of liquids that produce eye, skin, or respiratory irritation; (2) liquids or solids that produce eye injury or skin burns upon direct contact; and (3) chemcials that produce systemic poisoning when absorbed by inhalation, skin absorption or ingestion.

Water Pollution. Since large quantities of bulk chemicals are transported on inland waters, there is a serious possibility of impacting potable water supplies when chemicals are spilled. Water pollution ratings reflect the degree of concern that arises when chemicals are spilled or dumped in U.S. waters. A wide variety of problems arise from such occurrences: These are: municipal potable water systems may be rendered unfit for consumption; fish and other aquatic life may be killed; waters in streams or on beaches may be contaminated making them unfit for recreational purposes; or noxious odors or vapors may evolve from the spill to contaminate the atmosphere in areas nearby. The water pollution characteristics of chemicals are rated in three ways: (1) human toxicity, (2) aquatic toxicity, and (3) aesthetic effect.

Table IV–19
OUTLINE OF NAS RATING SYSTEM*

HAZARD CLASS	GRADE 0	GRADE 1	GRADE 2	GRADE 3	GRADE 4
FIRE	NO HAZARD	CLOSED CUP FLASH POINT ABOVE 140°F	FLASH POINT 100 TO 140°F	FLAST POINT BELOW 100°F, B.P. ABOVE 100°F	FLASH POINT BELOW 100°F, B.P. BELOW 100°F
HEALTH					
VAPOR IRRITANT	NO EFFECT	SLIGHT EFFECT	MODERATE IRRITATION; TEMPORARY EFFECT	IRRITATING; CANNOT BE TOLERATED	SEVERE EFFECT; MAY DO PERMANENT INJURY
LIQUID OR SOLID IRRITANT	NO EFFECT	CAUSES SKIN SMARTING	FIRST–DEGREE BURNS, SHORT EXPOSURE	SECOND–DEGREE BURNS, FEW MINUTES EXPOSURE	SECOND–DEGREE AND THIRD–DEGREE BURNS
POISONS	NO EFFECT	SLIGHTLY TOXIC	INTERMEDIATE TOXICITY	MODERATELY TOXIC	SEVERELY TOXIC
WATER POLLUTION					
HUMAN TOXICITY	NONTOXIC; LD_{50} 15 g/kg	PRACTICALLY NONTOXIC; LD_{50}m 5–15 g/kg	SLIGHTLY TOXIC; LD_{50} 0.5 to 5 g/kg	MODERATELY TOXIC; LD_{50} 50–500 mg/kg	TOXIC CHEMICALS; LD_{50} 50 mg/kg
AQUATIC TOXICITY	ACUTE THRESHOLD LIMITS ABOVE 10,000 ppm	THRESHOLD LIMITS 1,000 TO 10,000 ppm	THRESHOLD LIMITS 100 TO 1,000 ppm	THRESHOLD LIMITS 1 TO 100 ppm	THRESHOLD LIMITS BELOW 1 ppm
AESTHETIC EFFECT	NO SIGNIFICANT POLLUTION; GASES AND ODORLESS LIQUIDS	MILD–ODORED LIGHT OILS AND SOLUBLE CHEMICALS	MILD–ODORED, COLORLESS, WATER INSOLUBLE OILS; B.P. 150–450°F	LIGHT–COLORED HIGH–BOILING OILS; ODOROUS WATER–SOLUBLE COMPOUNDS	HEAVY OILS, COLORED OR MALODOROUS
REACTIVITY					
OTHER CHEMICALS	INACTIVE; MAY BE ATTACKED BY GRADE 4	REACT ONLY WITH GRADE 4	REACT WITH GRADES 3 AND 4	REACT WITH EACH OTHER AND WITH THOSE OF GRADES 2 AND 4	REACT WITH EACH OTHER AND ALL OTHER GRADES
WATER	NO REACTION	MILD REACTION; UNLIKELY TO BE HAZARDOUS	MODERATE REACTION	MORE VIGOROUS REACTION; MAY BE HAZARDOUS	VIGOROUS RACTION; LIKELY TO BE HAZARDOUS
SELF–REACTION	NO REACTION	MILD SELF–REACTION UNDER SOME CONDITIONS	WILL UNDERGO SELF–REACTION IF CONTAMINATED; DO NOT REQUIRE STABILIZER	VIGOROUS SELF–REACTION; REQUIRES STABILIZER	SELF–OXIDIZING CHEMICAL; CAPABLE OF EXPLOSION OR DETONATION

* These definitions were employed as a broad scheme in rating chemicals, but were not always followed rigidly. Ratings were shifted upward or downward to reflect other properties not shown in this brief outline.

Table IV–20
HAZARD RATINGS OF CHEMICALS OF VARIOUS TRANSPORT CONDITIONS

CHEMICAL CARGO TRANSPORT CONDITION	CHEMICAL CARGO	FIRE	HEALTH			WATER POLLUTION			REACTIVITY		
		I	II	III	IV	V	VI	VII	VIII	IX	X
			VAPOR IRRITANT	LIQUID/SOLID IRRITANT	POISONS	HUMAN TOXICITY	AQUATIC TOXICITY	AESTHETIC EFFECT	OTHER CHEMICALS	WATER	SELF-REACTION
(AP – AT) AMBIENT PRESSURE – AMBIENT TEMPERATURE) LIQUID CHEMICAL CARGO TRANSPORTED NEAR ATMOSPHERIC PRESSURE AND 70°F.	SULFURIC ACID (77–98%) H_2SO_4	0	2	4	2	2	3	2	4	3	0
(HP – AT) (HIGH PRESSURE – AMBIENT TEMPERATURE) PRESSURIZED LIQUEFIED CHEMICAL CARGO TRANSPORTED NEAR VAPOR PRESSURE OF CARGO AT 70°F.	CHLORINE Cl_2	0	4	2	4	2	3	2	4	1	0
(AP–LT) (AMBIENT PRESSURE – LOW TEMPERATURE) CRYOGENICALLY LIQUEFIED CHEMICAL CARGO TRANSPORTED NEAR ATMOSPHERIC PRESSURE AND BELOW ITS BOILING POINT.	AMMONIA, ANHYDROUS NH_3	1*	4	2	2	2	2	2	3	2	0
(AP – HT) (AMBIENT PRESSURE – HIGH TEMPERATURE) HEATED CHEMICAL CARGO TRANSPORTED NEAR ATMOSPHERIC PRESSURE.	SULFUR, MOLTEN S	1–3*[g]	1	1[c]	1	0	1	1	4[h]	0	0

*DENOTES CHEMICALS HAVING A FIRE HAZARD UNLIKE THE HYDROCARBONS. INCLUDES CHEMICALS CONTAINING NITROGEN, SULFUR, OR HALOGENS WHICH ON COMBUSTION MAY EVOLVE NOXIOUS GASES; PYROPHORIC COMPOUNDS; AND THOSE HAVING EXCEPTIONALLY HIGH OR LOW IGNITION TEMPERATURES OR NARROW COMBUSTION LIMITS.

[g] FIRE HAZARD OF COMMERCIAL SULFUR VARIES CONSIDERABLY WITH ORGANIC CONTENT.

[h] SULFUR AT 280°F. DOES NOT REACT VIGOROUSLY WITH GRADE 1 THROUGH 3 SUBSTANCES ON THE PRESENT LIST OF CHEMICALS AT THIS OR AT LOWER TEMPERATURES. IT IS GIVEN A 4 RATING IN COLUMN VIII DUE TO ITS ABILITY TO REACT WITH HYDROGEN-CONTAINING ORGANIC COMPOUNDS TO PRODUCE HYDROGEN SULFIDE.

SOURCE: Adapted from: "Evaluation of the Hazard of Bulk Water Transportation of Industrial Chemicals", A Tentative Guide, National Academy of Sciences, National Research Council, Washington D.C., 1966.

Reactivity. This class of hazard arises from the susceptibility of chemicals to undergo a chemical reaction under the conditions of bulk water transportation. Three types of hazards are considered: (1) the reaction of chemicals with each other; (2) the reaction of chemicals with water; and (3) self-reaction, usually polymerization or decomposition.

(4). Environmental Protection Agency (70). The Environmental Protection Agency's Oil and Hazardous Materials Technical Assistance Data System (OHM-TADS) is an automated information retrieval file designated to facilitate rapid-retrieval of information on 1,000 oil and hazardous substances.

The prime function of the files is to provide immediate feedback of information on hazardous substances to spill response team personnel. Individual segments contain both numerical data and interpretive comments. These can serve as background for decision making and guidelines to initiate corrective action.

The completed files can also be used as a source of diverse information on hazardous substances as a whole, allowing research and envorcement authorities to assess areas where more work or stricter regulations are needed.

The system includes a wide variety of physical, chemical, biological-toxicological, and commercial data. However, the greatest emphasis is placed on the deleterious effects these materials may have on water quality.

5. EFFECTS OF CHEMICAL SPILLS ON HUMAN HEALTH

a. OVERVIEW

Since accidental losses of chemicals from bulk waterborne carriers occur on or in the water, human exposure can occur either directly through bodily contact of the liquid, solid, or vapor state, or indirectly

through ingestion via drinking water or the food chain. Human health implications of such exposure have been carefully considered and rated by GESAMP (66) the U.S. Coast Guard (69), IMCO (60), and EPA (70). The following subsections discuss human health implications of noxious and hazardous substances.

b. CHEMICAL POISONS

Poisonous chemicals gain access to the body through inhalation (e.g., chlorine, chloroform, carbon tetrachloride, oleum, oxygen difluoride and tetraethyl lead), oral ingestion (e.g., DDT, ethyl mercury and dieldrin), and skin absorption (e.g., carbon tetrachloride, acrylonitrile, and analine). The type and severity of the toxic effects are dependent upon the particular chemical and its concentration in the body. Chemicals are also considered poisonous if they are anesthetics or narcotics or have a cumulative toxic effect, as well as if they are acutely toxic.

c. LIQUID AND SOLID IRRITANTS

Some hazardous substances will chemically "burn" or irritate human skin as a result of contact in the liquid or solid state (e.g., caustic soda, hydrochloric acid, hydroflouric acid, nitrogen tetra-oxide, and phenol). Chemicals which burn the skin are also severe in their effects on the eyes and membranes. Burns arising from heat (if in hot molten state) or cold (if in refrigerated state) can also occur.

d. VAPOR IRRITANTS

This type of hazard involved the toxicological effect of vapors and fumes evolved from the chemical and not to splashes of the liquid itself. The class includes gases, or those chemicals which emit vapors or fogs irritating to the skin or the mucous membranes of the eyes, nose, throat and lungs (e.g., n-butyraldehyde, carbon disulfide, cresols, diamino propane, dichloroethane, hydrocyanic acid, and hydrogen peroxide). When present in lower concentrations, many of the inhaled poisons mentioned above under chemical poisons fit into this class.

6. EFFECTS OF CHEMICAL SPILLS ON AQUATIC ORGANISMS

a. OVERVIEW

Effects of chemical spills on aquatic organisms have been classes into two general categories: (1) direct or acute toxic effects upon organisms; and (2) sublethal effects, including chronic toxicity. An element is said to be toxic if it injures the growth or metabolism of an organism when applied above a certain concentration (72). Definition of direct, acute and chronic toxicity adopted for use herein are those expressed by McKee and Wolf (73). Acute, or direct, toxicity is defined as the lethal action occurring within a period of 96 hours or less, while chronic toxicity involves deleterious effects which may not be evident for weeks, months or longer. Sublethal effects include the broad spectrum of direct and indirect effects, including chronic toxicity, which may occur in the aquatic environment as a result of chemical introduction.

b. DIRECT TOXIC EFFECTS

Direct toxic effects on aquatic organisms of a particular chemical have been found to vary both among species and between life stages of particular species (74). Portmann (75) concluded, as a result of his studies of 160 "pollutants" and review of the literature, that fish larvae are more sensitive than fully grown adults with LC_{50} (the concentration required to kill 50 percent of the animals in 48 hours) values varying by a factor of 3 to 100 times. He also observed that phytoplankton species appear to be more susceptible than adult marine animals.

The most important mode of toxic action is thought to be the poisoning of enzyme systems (72). For example, the outstanding toxicity of electronegative metals, notably copper and mercury, is related to their great affinity for amino, imino and sulfhydryl groups, which are doubtless reactive sites on many enzymes.

In view of the large number of enzymes in living cells, great variations of chemical toxicity levels are to be expected. Other modes of

toxic action result from: (1) behavior of pollutants as antimetabolites (2) formation of stable precipitates or chelates with essential metabolites; (3) catalyzation of the decomposition of essential metabolites; (4) combination with the cell membrane with resultant affectation of its permeability; and (5) replacement of structurally important elements in the cell with subsequent failure to function (72).

The extent of toxic effects is also regulated by the particular physical and chemical properties of the chemical as it interacts with environmental variables. For example, the toxicity of hydrogen cyanide will increase with a decrease in hydrogen ion concentration (pH), or with an increase in temperature (72). Chlorinated hydrocarbon pesticides are most toxic during summer rather than winter temperatures, and at least one of the common detergents becomes decidedly more toxic to fish as salinity levels increase (72). Spill location is also important. For example , insoluble, lighter than water substances may be more persistent in colder climates, where chemical and bacterial degradation is slow. Under such conditions accumulation can occur to create a hazard to aquatic life and wild life, (e.g., seals, polar bears, and other mammals living on and under the ice) (66).

Reactions of introduced chemicals dissolved organics and inorganic materials in the receiving waters may result in neutralization synergism or antagonism of one substance by another. These interactions in turn determine the ultimate effects on the aquatic organisms (66,69). The toxicity of heavy metals, which are less toxic in seawater than in freshwater, is regulated in this manner. In some instances, such as with endosulfan, the toxicity is actually higher in saline water than in fresh water (66).

These relationships are particularly important when chemical losses occur in already polluted areas, since the lost materials will tend, in some cases, to synergize and, in others, to antagonize the effects of existing pollutants. Where synergism occurs the net effect would generally be increased toxicity to already stressed organisms, and perhaps mortality, which might not have resulted from a spill occurring under

the original pollution conditions. In the case of antagonistic interaction, the net effect might occasionally be beneficial, since toxic effects would be at least temporarily reduced. Predictability of synergism and antagonism is difficult since little is understood about the basic mechanisms or fundamentals governing these processes (73).

Direct toxic effects are regulated to a large degree by the life history characteristics of organisms. In the sea, dilution of wastes is frequently very rapid so that levels which are directly toxic to fish are found only in the immediate vicinity of the point of discharge and usually persist for a relatively short period of time (76). Most fish species have the capacity to swim away from such short term toxic concentrations, although they do not always do this, and indeed, may be attracted by certain substances (e.g. phenols) (76). Visual evidence of fish kills are generally transient, since dead and dying fish sink, are carried away by currents, or are eaten by sea birds. Lobster, crab, and shrimp can move away from unfavorable areas, (although relatively slowly) (76). As a result of their immobility, oysters, mussels, and cockels have to cope with anything brought to them by tides, currents, or winds. If necessary these organisms have a temporary defense mechanism of being able to close their shells and exclude poisonous substances for several hours or even days. Losses are most likely to occur in estuaries and shallow semi-enclosed coastal bays and inlets where both the volume of water and capacity for quick dilution or dispersal are limited (76).

c. SUBLETHAL EFFECTS

As used herein, the term sublethal effects is that described by Mitrovic (77) and refers to effects of all concentrations not necessarily lethal for individuals, even at prolonged exposures, but increase the population mortality, decrease its size or change its composition.

The effect on aquatic organisms of small quantities of various toxic materials, although generally less apparent than sudden fish kills, may be even more harmful. This circumstance demonstrates why it is difficult to establish safe concentrations of toxic substances (77). Substances most likely to cause long-term effects at low concentrations are

those which are persistent in the environment and are accumulated in animals and plants or in the bottom sediment (76). Lists of these substances have been cited by GESAMP (66), Idler (78), and USCG (69).

Sublethal concentrations of chemicals or their reactant products may affect reproduction in many different ways. Induced abnormal development of embryos may result in deformed or non-functioning larvae, which cannot survive hatching. Reproduction may be influenced by induced behavioral changes in the adults during the mating season. Adult behavior and the production of egg nutrients and egg shells may all be affected by change of hormone function and enzyme activity (79). Alderson (80) found that very low levels of chlorine would produce significant larval and egg mortalities (e.g., LD_{50} 0.024-0.34 ppm for larvae and 0.07-0.12 ppm for eggs.) Davis (79) cited a study by Kinne and Rosenthal which showed that in concentrations of $FeSO_4$ and H_2SO_4 as low as 1:32,000, the percentage of successful fertilization of herring (Clupea harengus) eggs was reduced, embryonic growth rate was retarded, the embryonic heat frequency was enhanced (stress), the duration of incubation was decreased, the percentage of successful hatchings was reduced, and the occurrence of structural abnormalities in the hatchings was increased.

Nutrient containing or yielding chemicals may lead or contribute to eutrophication in some waters. This tends to be truer in enclosed water areas, particularly in the tropics. Since bacterial activity has been demonstrated to be temperature dependent (66) it is anticipated that degradation of spilled chemicals will be most rapid in warm tropical waters and slowest in cold arctic waters. Chemicals which are readily biodegradable in temperate waters, may, due to temperature related persistence, have significant long-term consequences in the Arctic (66). Compounds exhibiting high biological oxygen demand (BOD), such as molasses, can have chronic, as well as acute, toxic effects, particularly in tropical and semi-tropical waters (66).

Many chemicals or their reactants will find their way to the bottom. For example, colloidal clay suspensions, available from inflowing fresh

water run-off, will absorb certain chemicals, including nutrients and pesticides, which in turn will reach the bottom as the clay is flocculated on mixing with seawater (66). Others will be deposited after reaction with plankton and other suspended organic matter. Some, such as phosphorous, tetraethyl lead, and liquid sulfur, will sink to the bottom since they are heavier than seawater and not highly soluble.

Once at the bottom, substances such as heavy metals, pesticides, and nutrients are incorporated in the sediments where they may cause toxic effects on benthos and other organisms frequenting the water mass near the bottom. However, it does not necessarily follow that the chemical has found a final resting state, since oxidation-reduction reactions may cause them to be released or currents may transport them to other locations.

Ranchor (81) reported on the release of waste acid off Helgoland (German Bight) containing about 10% H_2SO_4, 14% $FeSO_4$ and also mineral pollutants. Bottom samples showed a loose mass of Fe (III) oxide-hydrate flakes floating above the sediment. Under laboratory conditions, this waste acid was found to have harmful effects even in great dilution. However, field studies were not so conclusive. Although faunal collections indicated a change in benthic species composition, it was considered impossible to prove any harmful effect to the macrofauna. Some macrofaunal species, originally scarce in the research area, now exist there in great numbers, making up more than 50% of the total organisms. This could be due to the natural processes, or it may have been favored by the waste disposal. Chemicals which cause suspensoids may, on occasion, significantly reduce light penetration and, in so doing, affect the growth of bottom algae and reduce phytoplankton production (76).

Avoidance reactions to various toxic chemicals have been observed for both fish and other organisms. These reactions impact organisms in various ways. For example, Portmann (75) found that European brown shrimp (Crangon crangon) were able to detect and escape from 3.3-10 ppm of H_2SO_4 and 10-33 ppm of phenols, indicating that this species can through avoidance probably escape direct toxicity from spill incidents. Chemical losses may have significant impacts when they cause avoidance

reactions at critical times or locations. Mitrovic (77) cited a study by Kalakiner which concluded that fish would not inhabit parts of a river with phenol content higher than 0.2 mg/l, while Ishio (82) described an imbalanced fish distribution in the Onaga River (Japan) where parts of the river were polluted by coal washing wastes containing phenol in concentrations 0.024-0.1 mg/l. Elson (83) concluded that slow upward passage of Atlantic salmon (salmo solar L.)through the Miramitchi River (Canada) appears to be attributed to the Miramitchi's burden of industrial pollution.

Some substances often accumulate in organisms or bottom sediments from which they can be taken up by bacteria and bottom living organisms (67). Once accumulating in the food chain, they may eventually reach concentrations of sufficient level to harm the involved organisms life history stages. Through concentrations in parts of fish and shellfish, the substances may result in public health hazards and economic losses due to tainting problems. Substances most commonly implicated in tainting of fish and shellfish are oil, phenols and cresols (76).

Since chemicals may be washed ashore at any point and may be deposited directly on the inter-tidal zone, the filter-feeding shellfish such as mussels and oysters are most frequently affected although lobsters and crabs may be similarly affected. Idler (78) cites a study by Nitta which concludes that bitter tastes from soft clams in a river estuary may be due to the presence of polluting metabolites of aromatic compounds.

7. VAPOR HAZARDS ASSOCIATED WITH THE SEA TRANSPORT OF CERTAIN CHEMICALS IN BULK (84)

This section considers the potential hazard resulting from the inadvertant release of certain chemical cargoes which subsequently give rise to a fire,explosion, or toxic vapor condition. The conditions leading to the release of the cargo are not discussed; only the potential magnitude or extent of the hazard is considered. The most serious hazards are vapors from liquefied gas releases. For example, liquefied petroleum gas (LPG) presents a potential fire and explosion hazard, liquefied natural gas (LNG) a fire hazard (explosive only if confined), while ammonia and

chlorine pose toxic hazards. It is important to bear in mind that, whereas atmospheric concentrations on the order of 25,000 parts per million (ppm) can indicate flammable hazards, concentrations as low as 100 ppm can pose serious toxic problems.

Table IV-21 gives pertinent physical properties and shipping hazards of these chemicals. It can be seen from the Table that the individual properties of the substance have marked effects on both the nature and severity of the hazard.

a. EXTENT OF VAPOR HAZARDS

Following an inadvertent spill of a liquefied gas on water, rapid vaporization takes place immediately, primarily due to heat input from water. Normally the heat from the atmosphere is much less and can be neglected. Since the resulting vapors are carried downwind, it is necessary to know the extent or range of flammable or toxic concentrations. As previously indicated, typical flammable concentrations are on the order of 100 times greater than toxic concentrations. Therefore, for vapors of comparable density, the downwind toxic hazard spread will be much greater than the flammable hazard.

LPG vapor dispersions from spills on water have not been reported although LPG vapor dispersion and fire radiation tests are now being conducted for the U.S. Coast Guard at the Naval Weapons Station, China Lake, California. Since LPG vapors are much heavier and possess a lower flammable limit in comparison to LNG vapor, it is possible that the extent of flammable vapor concentrations downwind for LPG could be greater than for LNG. However, LPG has a lower vaporization rate (.03 vs. .04 lb/sec.-ft^2) which may counteract this effect. The tests now underway at China Lake will verify the assumptions and theoretical models available at the present time.

LNG vapor dispersions from spills on water have been the subject of extensive, independent studies by the U.S. Bureau of Mines Safety Research Center (85) for the U.S. Coast Guard, Exxon Research and Engineering Company (86) and the Thorton Research Centre of Shell Research

Table IV–21
CHEMICAL PROPERTIES AND SHIPPING HAZARDS

CHARACTERISTICS	LIQUEFIED PETROLEUM GAS (LPG)	LIQUEFIED NATURAL GAS (LNG)	AMMONIA, ANHYDROUS (AMA)	CHLORINE (CLX)
COMMON SYNONYM	Propane – butane – (propylene), Pyrofax, LPG	LNG	Liquid Ammonia	
DESCRIPTION	Liquefied gas, Colorless, Weak odor; may have skunk odor added. Floats and boils on water. Flammable vapor cloud is produced.	Liquefied gas, Colorless, Odorless or weak skunk odor Floats and boils on water. Flammable visible vapor cloud is produced.	Liquefied gas Colorless, Ammonia odor Floats and boils on water. Poisonous, visible vapor cloud is produced.	Liquefied gas, Greenish yellow, Irritating, bleach-like choking odor Sinks and boils in water. Poisonous, visible vapor cloud is produced.
PHYSICAL & CHEMICAL PROPERTIES				
PHYSICAL STATE AT 15°C and 1 atm.	Gas	Gas	Gas	Gas
BOILING POINT AT 1 atm.	>–40°F = >– 40°C = >233°K	–258°F = –161°C = 112°K	–28.1°F = –33.4°C = 239.8°K	–29.4°F = –34.1°C = 239.1°K
SPECIFIC GRAVITY	0.51–0.58 at –50°C (liquid)	0.415–0.45 at –162°C (liquid)	0.682 at –33.4°C (liquid)	1.424 at 15°C (liquid)
VAPOR (GAS) SPECIFIC GRAVITY	1.5	0.55–1.0	0.6	2.4
FIRE HAZARDS				
FLASH POINT	Propane, –156°FC.C., Butane, – 76°FC.C.	Flammable Gas	Not flammable under	Not flammable.
FLAMMABLE LIMITS IN AIR	Propane, 2.2 – 9.5% Butane, 1.8 – 8.4%	5.3 – 14.0%	15.5 – 27.0%	Not flammable.
IGNITION TEMPERATURE	Propane, 871°F, Butane, 761°F	999°F	1204°F	Not flammable.
NAS HAZARD RATING FOR BULK WATER TRANSPORTATION				
FIRE	4	4	1	0
HEALTH				
VAPOR IRRITANT	0	0	4	4
LIQUID OR SOLID IRRITANT	0	0	2	2
POISONS	0	0	2	4
WATER POLLUTION				
HUMAN TOXICITY	0	0	2	2
AQUATIC TOXICITY	0	0	2	3
AESTHETIC EFFECT	0	0	2	2

Table IV--21 (Cont'd.)

CHARACTERISTICS	LIQUEFIED PETROLEUM GAS (LPG)	LIQUEFIED NATURAL GAS (LNG)	AMMONIA ANHYDROUS (AMA)	CHLORINE (CLX)
REACTIVITY				
OTHER CHEMICALS	0	0	3	4
WATER	0	0	2	1
SELF–REACTION	0	0	0	0
WATER POLLUTION				
AQUATIC TOXICITY	None	None	0.3–0.4 ppm/*trout fry/ toxic or lethal/fresh water 0.7 ppm/6.5 hr/rainbow trout/toxic or lethal/ fresh water	0.08 ppm/168 hr/trout/ TL_m/fresh water 10 ppm/1 hr./tunicates/ killed/salt water
WATERFOWL TOXICITY	None	None	120 ppm 120 ppm	Data not available
BIOLOGICAL OXYGEN DEMAND (BOD)	None	None	Not pertinent	None
FOOD CHAIN CONCENTRATION POTENTIAL	None	None	None	None

* Time period not specified.

SOURCE: Adapted from, Chris Hazardous Chemical Data, CG--446–2, January 1974.

Limited (87) in behalf of the American Petroleum Institute. The Shell tests were conducted on a laboratory scale, whereas the Bureau of Mines and Esso studies included much larger field tests.

Results of the Shell test vaporization rates varied from 0.006 to .040 lb/sec-ft^2, with the latter value being the maximum observed and the Bureau of Mines and Esso, test results were .032 to .037 lb/sec-ft^2 and 0.04 lb/sec-ft^2 respectively. Other small scale tests performed independently by Continental Oil Company, Massachusetts Institute of Technology and University Engineers tend to confirm the results first reported by the Bureau of Mines.

To circumvent this apparent discrepancy in evaporation rates which introduces at least a factor of two in the downwind dispersion distances, it was decided to calculate downwind dispersion distances for continuous steady state spills on water. The results of these calculations are summarized in Figure IV-10. This calculation technique is similar to that used by the Bureau of Mines.

The concentrations reported in Figure IV-10 are time averages. However, it has been observed that the concentration at any point undergoes a variation due to atmospheric fluctuations. Therefore, it is necessary to establish the magnitude of this fluctuation, which is commonly referred to as the peak-to-average concentration. The extent of the flammable region should be based on these peak concentrations, rather than the time-average values. The peak-to average concentration is a function of several variables, including wind speed and atmospheric conditions.

The peak-to-average concentration can vary from more than 10 to 1 for unstable atmospheric conditions down to about 1.5 to 1 for stable conditions. Stable atmospheric (Brookhaven D) conditions usually result in a long downwind range and are used for "worst-case" hazard evaluations so the error involved in omission of the peak-to-average values is not critical. In addition, the uncertainties in the many other parameters which govern the extent of vapor dispersion is not as important for toxic vapor dispersions because the toxic limits are average values for periods ranging from a few minutes to several hours.

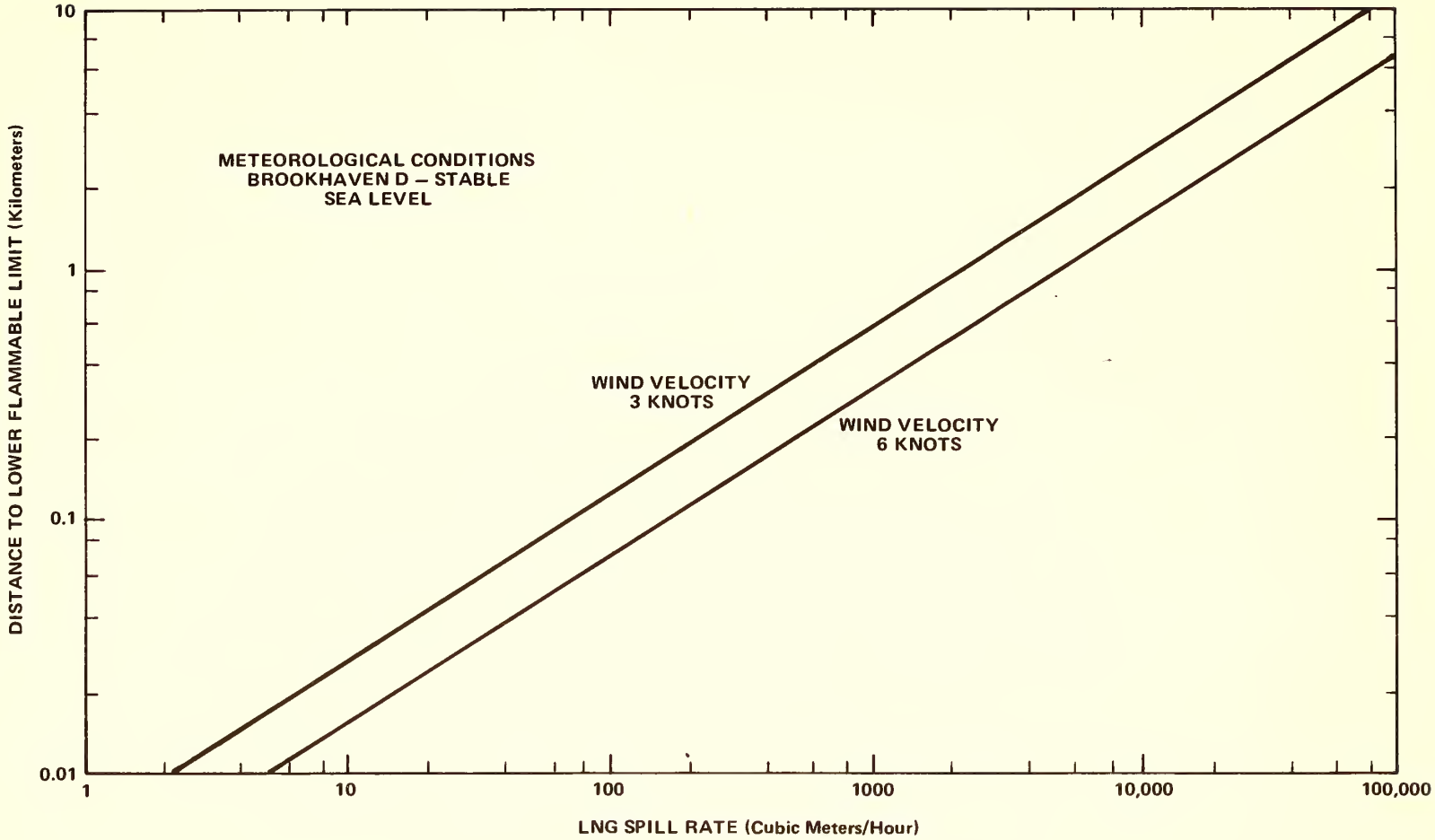


Figure IV–10 THE EFFECTS OF SPILL RATE AND WIND VELOCITY ON THE DOWNWIND DISPERSION OF FLAMMABLE LNG VAPORS

SOURCE: Adapted from: Burgess, D., J. Biordi and I. Murphy, Hazards of Spillage of LNG into Water, U.S. Bureau of Mines, September 1972.

Chlorine vapor dispersions following a spill on water pose a severe toxic hazard in that an exposure to a concentration of 100 ppm for a minute or so can be extremely dangerous. In 1970 the U.S. Bureau of Mines Safety Research Center released a report on the hazards of marine transportation of liquid chlorine (85). Since the density of chlorine gas is more than twice the density of air, chlorine vapors tend to layer on the surface during downwind dispersions. Even though chlorine is soluble in water, the Bureau of Mines reported little evidence of chlorine absorption at the water interface. Figure IV-11 shows the predictions by University Engineers for the steady-stage downwind travel of vapors having a concentration of 100 ppm as a function of a continuous spill rate. Stable (Brookhaven D) atmospheric conditions and a wind veloctiy of 3 knots was used for this calculated estimate. Corrections for vapor density effects were not included. This figure dramatically illustrates that even minor releases of chlorine vapors cannot be tolerated, particularly since concentrations of 100 ppm are five to ten times higher than what is considered dangerous for exposures of one half hour duration.

Since the lower flammable limit of ammonia is about 160,000 ppm as compared to a toxic concentration of 1,000 ppm (for very short durations of a few minutes), ammonia vapor dispersions should be classed primarily as a toxic hazard. In contrast tc chlorine and LPG, ammonia vapors are less dense than air; therefore, they will tend to layer less and disperse vertically due to the effects of buoyancy. Figure IV-12 summarizes the predictions by University Engineers for the downwind travel of a vapor cloud having concentration of 1,000 ppm. For these calculations, it was assumed that 85 percent of the ammonia spilled on water vaporized, and the remainder dissolves in the water.

D. SPILL PROBABILITY AND RISK

A survey by the Oceanographic Institute of Washington (88) of tanker casualties for seven major port areas in the United States (for the time frame 1969-1972) found there is a good correlation between tanker casualties and tanker trips. The port areas are as follows:

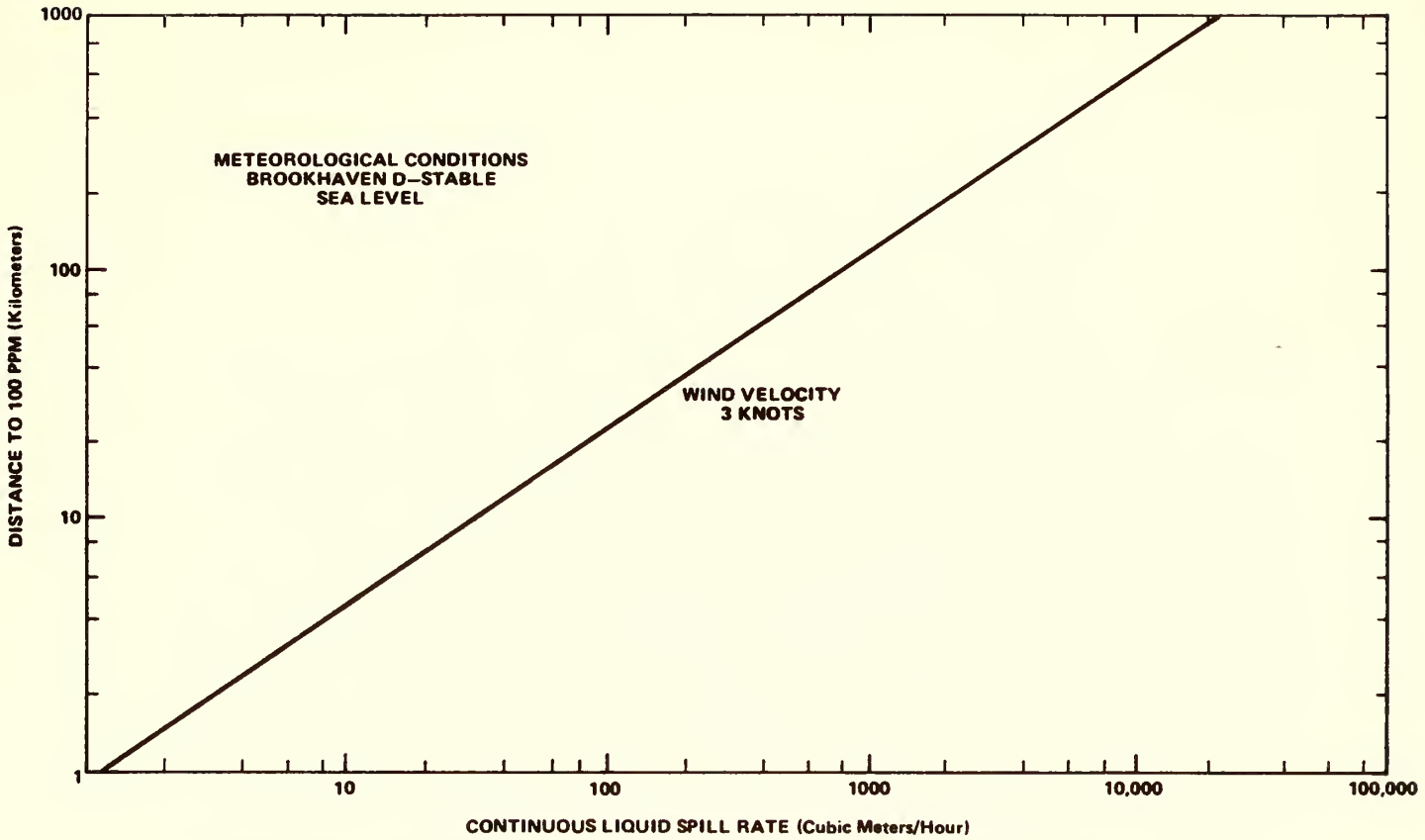


Figure IV–11 THE EFFECT OF SPILL RATE ON THE DOWNWIND DISPERSION OF CHLORINE VAPOR

SOURCE: Adapted from: Sliepcevich, C.M., Possible Hazards Associated with the Sea Transport of Liquefied Gases in Bulk, Committee on Hazardous Materials, National Academy of Sciences – National Research Council, Washington, D.C.

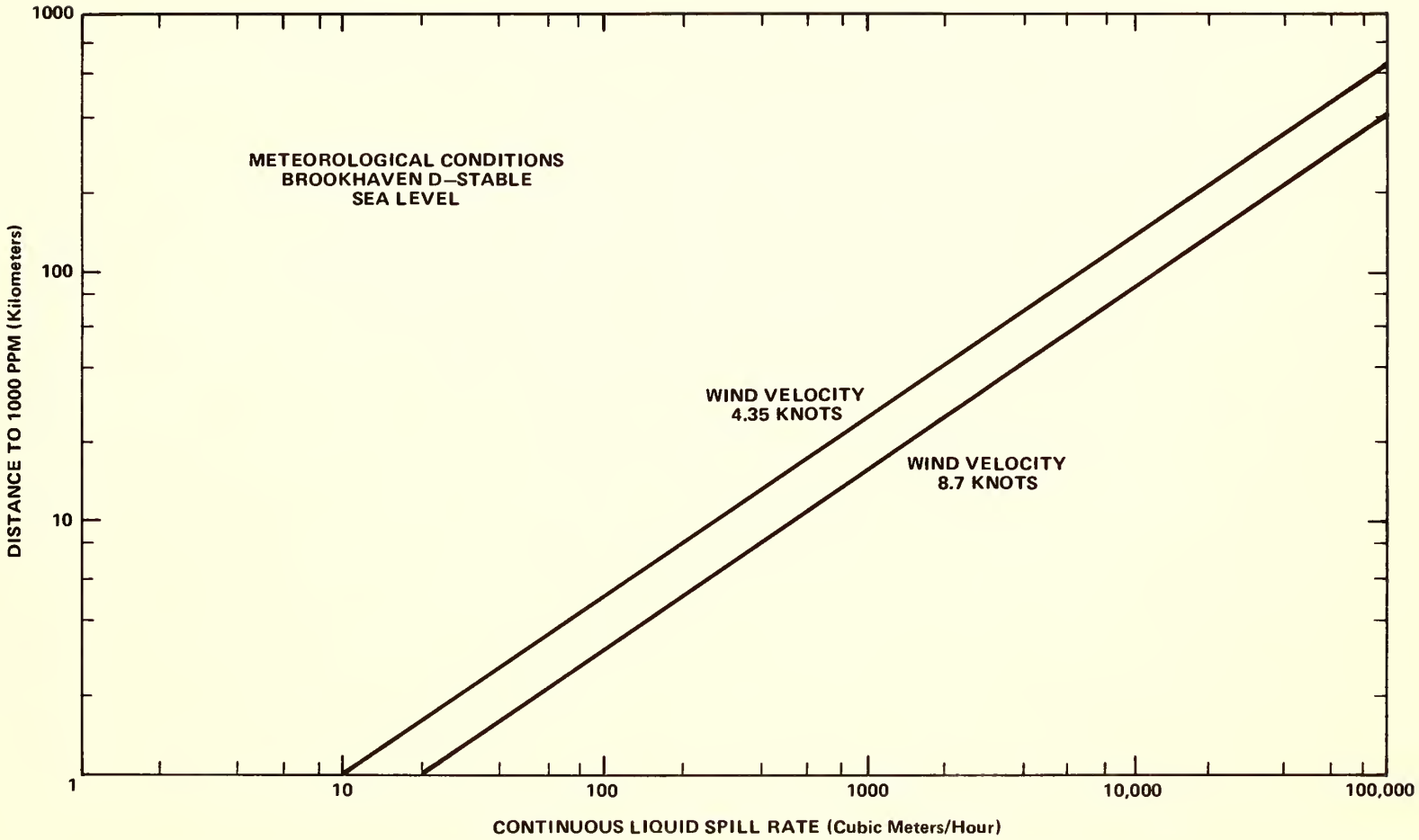


Figure IV–12 THE EFFECT OF SPILL RATE AND WIND VELOCITY ON THE DOWNWIND DISPERSION OF AMMONIA

SOURCE: Adapted from: Sliepcevich, C.M., Possible Hazards Associated with the Sea Transport of Liquefied Gases in Bulk, Committee on Hazardous Materials, National Academy of Sciences – National Research Council, Washington, D.C.

- New York, including the ports of New Haven and Bridgeport, Conn., and Port Jefferson and New York, N.Y.;
- Delaware Bay, encompassing that area extending from the mouth of the Delaware River upstream to Trenton, New Jersey, including the ports of Philadephia, Trenton, and others;
- Chesapeake Bay, including the ports of Baltimore and Hampton Roads, all associated entrances and approach channels:
- Gulf Coast, including all U.S. coastal ports from the Mexican border to the Sabine-Nachez Waterway;
- Los Angeles/Long Beach, including the ports of Los Angeles, Long Beach, San Diego, and associates waters;
- San Francisco, including all ports located inland of the entrance to San Francisco Bay;
- Puget Sound, including that area from the Columbia River to Cape Flattery, the Strait of Juan de Fuca, Puget Sound, and northern waters to the Canadian border.

The results of their analysis indicated that there is no significant difference among the mean casualty rates for various years. They also showed the casualty rates are constant from one U.S. port to the next. By combining U.S. Coast Guard casualty data with the cargo volume throughput and vessel trip data compiled by the U.S. Army Corps of Engineers (Waterborne Commerce in the United States), it was possible for the Institute to define a relationship among the three variables, i.e., casualties, cargo volume throughput and vessel trips. Figures IV-13 and IV-14 illustrate the results of this procedure. In Figure IV-13, adjusted casualties include all casualties involving U.S. flag vessels greater than 7000 DWT. Adjusted trips include all vessel round trips by tankers under U.S. flag registry. Since data pertaining to vessel trips in U.S. ports is not compiled in a form that differentiates between vessel registries, the following relationship was assumed:

$$\frac{\text{No. U.S. Flag Tanker Roundtrips}}{\text{Total No. of Tanker Roundtrips}} = \frac{\text{Total Bulk Petroleum water borne Commerce (excluding Foreign Commerce)}}{\text{Total Bulk Petroleum Waterborne Commerce}}$$

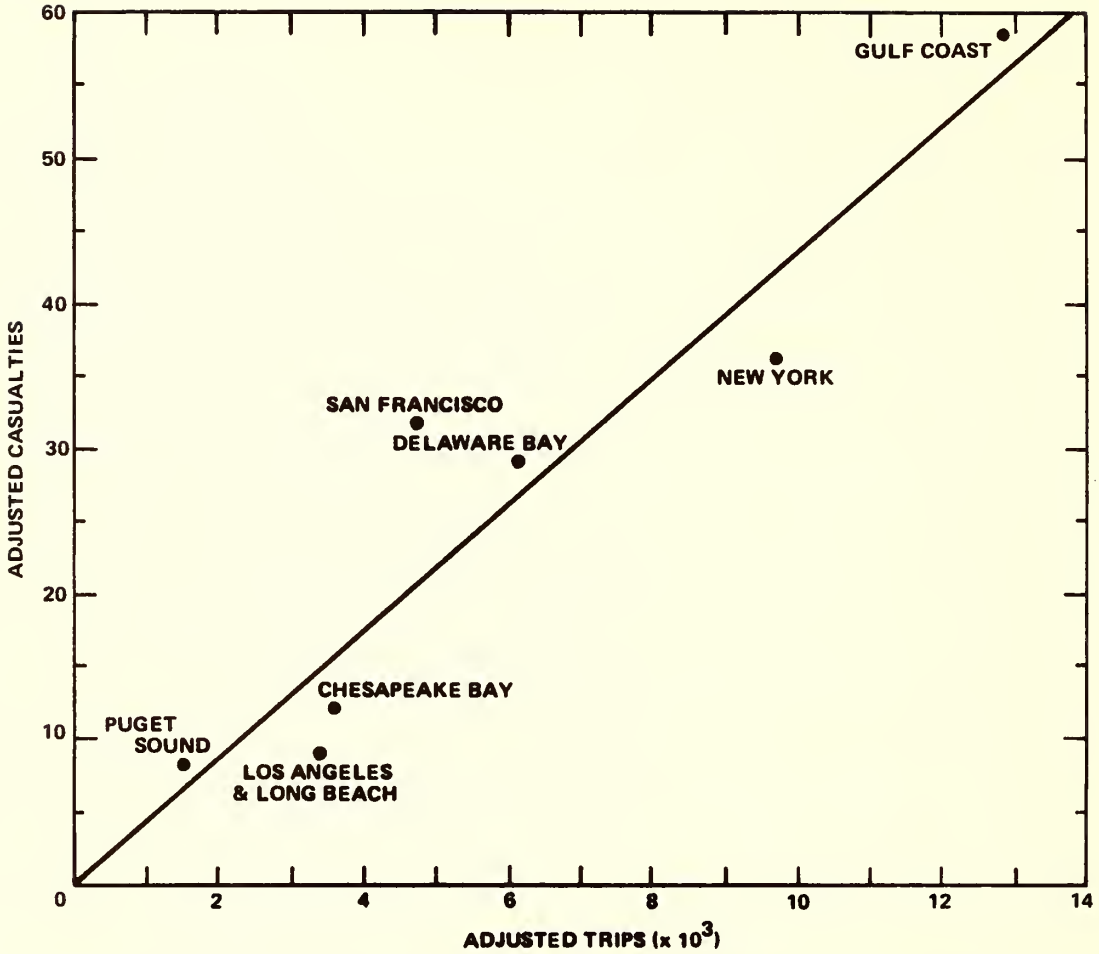


Figure IV–13 TANKER CASUALTIES VERSUS TANKER TRIPS (1969–1972)

SOURCE: Offshore Petroleum Transfer System for Washington State A Feasibility Study; prepared by the Oceanographic Institute of Washington for the Oceanographic Commission of Washington, December 16, 1974, Page V–45.

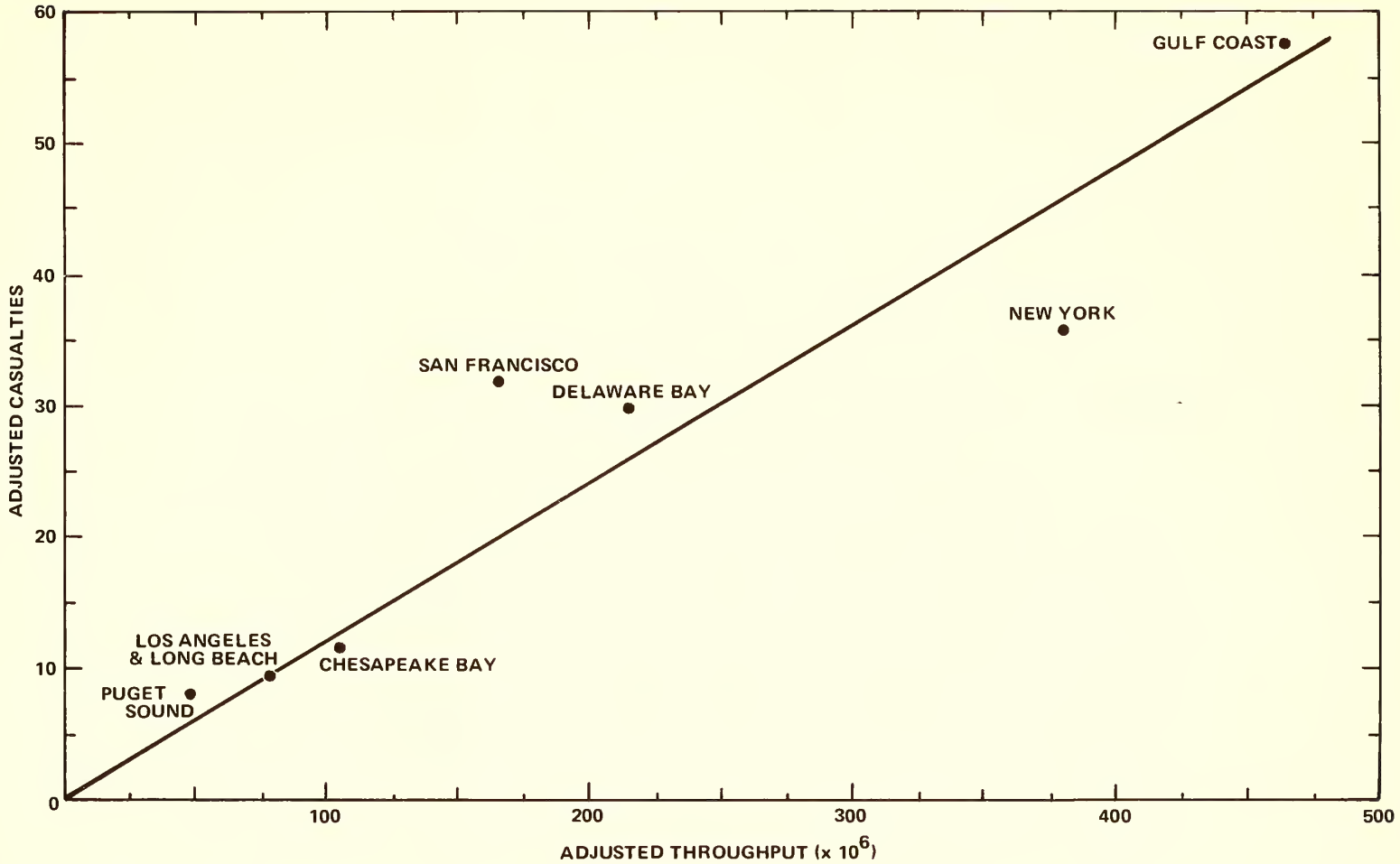


Figure IV—14 TANKER CASUALTIES VERSUS VOLUME THROUGHPUT (1969—1972)

SOURCE: Offshore Petroleum Transfer System for Washington State, A Feasibility Study; prepared by the Oceanographic Institute of Washington for the Oceanographic Commission of Washington, December 16, 1974, Page V—45.

Thus, the actual number of U.S. flag tankers is estimated by assuming the number of U.S. flag vessel trips is proportional to the volume of petroleum and petroleum products transported by U.S. flag vessels. The resulting plot of casualties versus trips illustrated in Figure IV-13 shows a strong linear relationship having a slope of .0044 casualties/vessel trip. The relationship between vessel casualties and petroleum volume throughput of Figure IV-14 illustrates a similar strong correlation having a slope 0.119 casualties/volume throughput. This analysis has demonstrated that the probability of a tanker casualty and a resulting oil spill is highly dependent on the frequency of vessel transits. Therefore, the risk potential at each port is sensitive to changes in the fleet mix, i.e., Alternate vessel sizes. From a risk viewpoint, the use of large numbers of relatively small tankers will increase the potential for vessel casualties in a particular port area. Recent trends indicate oil companies will use high capacity vessels to avoid the substantial economic penalties resulting from the use of relatively small tankers. Small tankers because of their much higher ton-mile costs, are unsuitable for long trips. Larger tankers will rapidly displace smaller vessels particularly in the Alaskan trade. From a risk viewpoint, the use of very large tankers would reduce the level of tanker transits in certain U.S. harbors and thereby reduce the potential for a vessel casualty. Although the probability of a vessel casualty will be reduced, the extent of the hazard may be much greater because of the probability of a larger spill volume.

The estimates of the casualty rate (number of tanker casualties/tanker trips) previously presented are without regard to the probability of a spill. It is likely that only a small portion of accidents would be sufficiently severe to cause the rupture of a cargo tank and the spillage of liquid cargo. Here the probability of a spill based on pollution causing-incidents (PCI) for petroleum tankers is estimated.

The recent analysis of worldwide tanker accidents prepared by the Office of Technology Assessment (OTA) Oceans Program (5) provides a basis for estimating spill probability. The analysis differentiates between

non-polluting accident types and pollution-causing-incidents (PCI's). The number of tanker accidents with associated pollution incidents for each type of accident is presented in Table IV-22. A spill frequency can be calculated by dividing the number of pollution incidents by the total number of accidents for each accident type as shown in column two. An annual tanker accident rate and an annual Pollution-Causing-Incident rate can be calculated by dividing the number of accidents and number of pollution causing incidents by six years as shown in columns three and five, respectively. An examination of the estimated annual rates reveals the interesting conclusion that collisions, groundings, rammings and structural failures appear to be the four most frequent type of events for both tanker accidents and Pollution-Causing-Incidents.

Table IV-22 provides the basis for estimating the fraction of Tanker Casualties which could be of sufficient magnitude to cause a spill. An analysis of incident frequency alone can be misleading, however, if the associated spill volume is not considered. Actual oil outflows can range from minimal spills to total loss of the tanker. In their analysis, the OTA differentiated between catastrophic spills and non-catastrophic spills. Table IV-23 shows the number and magnitude of 519 pollution incidents for different types of tanker accidents. The OTA staff with the assistance of ECO, Inc. concluded the following:

- If catastrophic (very large) events are excluded, groundings account for over twice the oil outflow than that of collisions and together they represent over 80 percent of the oil pollution from the accidents studied.

- If all events are included, structural failures are the largest single cause of oil spills and groundings are second largest.

- If only catastrophic (very large) events are included, structural failures are the largest single cause of oil spills and groundings and collisions are about equal as the second largest.

Table IV–22
NUMBER AND TYPE OF WORLDWIDE TANKER ACCIDENTS [1.] AND POLLUTION CAUSING INCIDENTS (PCI'S) [2.]

TANKER ACCIDENT TYPE	NO. OF PCI's/ NO. OF TANKER ACCIDENTS [3.]	FRACTION OF ACCIDENTS RESULTING IN SPILLS [4.]	ANNUAL PCI RATE [4.]	MOST FREQUENT PCI TYPES [4.]	ANNUAL TANKER ACCIDENT RATE [4.]	MOST FREQUENT TANKER ACCIDENT TYPES [4.]
BREAKDOWNS	12 / 403	0.03	2.0	–	67.1	–
COLLISIONS	147 / 877	0.17	24.5	X	146.2	X
EXPLOSIONS	40 / 127	0.31	6.7	–	21.2	–
FIRES	17 / 233	0.07	2.8	–	38.8	–
GROUNDINGS	144 / 935	0.15	24.0	X	155.8	X
RAMMINGS	51 / 543	0.09	8.5	X	90.5	X
STRUCTURAL	104 / 586	0.18	17.3	X	97.7	X
ALL OTHERS	4 / 5	0.80	0.7	–	0.8	–
TOTAL [3.]	519 / 3709	0.14	86.5	–	618.2	–

NOTES:
1. Involves tankers 2000 GRT and greater during the period 1969 to 1974
2. Catastrophic events are included
3. Source: "An Analysis of Oil Tanker Casualties 1969 – 1974", prepared by OTA Oceans Program for the Use of the U.S. Senate Committee on Commerce, Science and Transportation, Washington, D.C., February 7, 1978
4. Estimates by Ecology and Environment, Inc., 1978.

Table IV–23
NUMBER AND MAGNITUDE OF WORLDWIDE POLLUTION CAUSING INCIDENTS (PCI'S) BY TYPE OF TANKER ACCIDENT [1.]

TYPE OF ACCIDENT LEADING TO PCI [2.]	TYPE OF EVENT		
	CATASTROPHIC EVENTS INCLUDED	CATASTROPHIC EVENTS EXCLUDED	CATASTROPHIC EVENTS ONLY
BREAKDOWNS	12 / 48,763	9 / 590	3 / 48,173
COLLISIONS	147 / 226,884 (22%) [3.]	138 / 58,240 (27%)	9 / 168,644 (21%)
EXPLOSIONS	40 / 134,610 (13%)	25 / 7,326	15 / 127,284 (16%)
FIRES	17 / 2,935	16 / 1,685	1 / 1,250
GROUNDINGS	144 / 309,824 (31%)	130 / 122,925 (57%)	14 / 176,899 (22%)
RAMMINGS	51 / 14,506	51 / 14,506 (7%)	0 / 0
STRUCTURAL FAILURES	104 / 340,727 (34%)	89 / 18,208 (9%)	15 / 322,519 (41%)
ALL OTHERS	4 / 54,911	1 / 121	3 / 54,790
TOTAL	519 / 1,133,160	459 / 223,601	60 / 899,559

NOTES: 1. Involving tankers 2000 GRT and greater during the period 1969 to 1974

2. Number of PCI's /Total Outflow (Long Tons)

3. Relative percentage of oil outflow of the four major accident types are given in parentheses

SOURCE: Adapted From " An Analysis of Oil Tanker Casualties 1969 – 1974", prepared by OTA Oceans Program for the Use of the U.S. Senate Committee on Commerce, Science and Transportation, Washington, D.C., February 7, 1978.

It should be noted that the data from these studies were analyzed to determine the amount of oil pollution resulting from worldwide tanker casualties which may be orders of magnitude greater than the pollution from Title XI Program tankers engaged in domestic trade. It is difficult to assess the amount of oil pollution attributed to U.S. flag vessels engaged in domestic trade; however, spill incidence rates of U.S. flag vessels as compared to foreign flag vessels have been estimated (89).

Based on an estimate of port visits and Coast Guard PIRS data, equivalent spill incidence rates by flag for 1973 through 1975 were calculated and are illustrated in Figure IV-15. The estimates in Figure IV-15 are based on the assumption there is one U.S. port visit for vessels in import/export trade for every two U.S. port visits for vessels in domestic coastwide trade. In addition, it was assumed that vessel port visits are distributed among flags of registry in proportion to the relative tonnage of crude and petroleum products imported/exported. The numbers illustrated graphically in Figure IV-15 show that U.S. ships have about 50 percent as many spills per port visit as Liberian tankers, and about 20 to 30 percent as many spills per port visit as foreign tankers in general.

1. TANK BARGES

A safety analysis of barge cargo losses on inland waterways as a result of marine casualties was conducted by Marad, for the period July 1968 through June 1973 (61). Table IV-24 shows a frequency distribution of the 255 barges included in the analysis. Of the 229 barges for which information was available, 104, or 45%, experienced some loss of cargo as a result of an accident.

Table IV-25 indicates the accident rate per million miles in each inland waterway segment for barges carrying hazardous materials. For the ten bulk liquid chemical movements in the study, methanol has the highest probability of spill. The expected annual accidental spill rate of 0.0465 is equivalent to one spill every 22 years. That is, the recurrence interval for this type of spill would be every 22 years if conditions remained unchanged. Other recurrence intervals range as

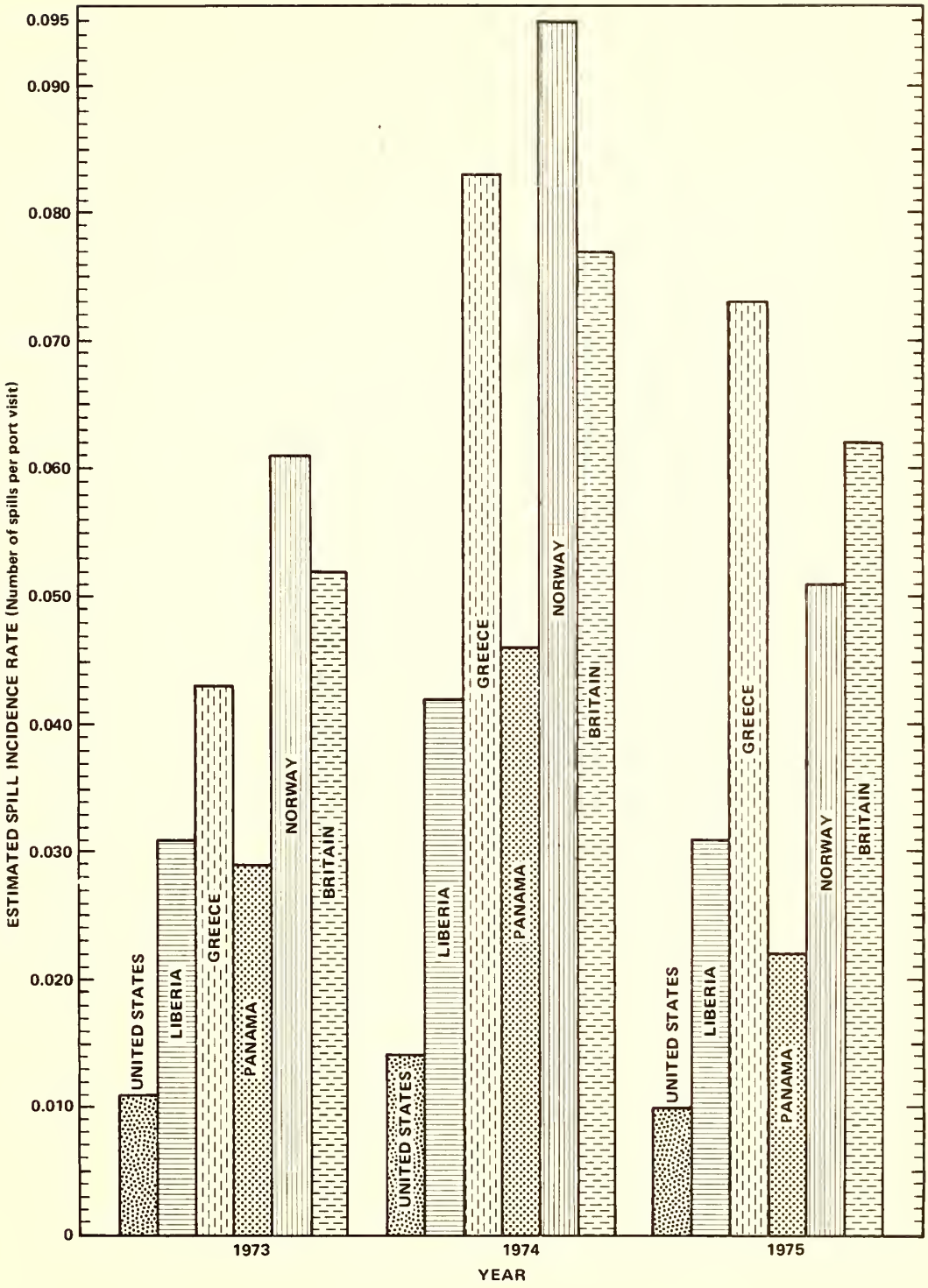


Figure IV–15 COMPARISON OF U.S. AND FOREIGN FLAG TANKER SPILL INCIDENCE RATES IN U.S. WATERS FROM 1973 TO 1975

SOURCE: Adapted from: Stewart, R.J., "Tankers in U.S. Waters", Oceanus, Vol. 20, No. 4, 1977, page 81.

Table IV–24
FREQUENCY DISTRIBUTION OF DOLLAR VALUE OF LOST CARGO FOR BARGES IN ACCIDENTS
July 1968 – June 1973*

	NUMBER OF BARGES	PERCENT OF TOTAL
$ 1 – $ 100	8	7.7
$ 101 – $ 500	15	14.4
$ 501 – $ 1,000	16	15.4
$ 1,001 – $ 2,000	11	10.6
$ 2,001 – $ 4,000	13	12.5
$ 4,001 – $ 6,000	10	9.6
$ 6,001 – $ 8,000	4	3.8
$ 8,001 – $10,000	11	10.6
$10,001 – $20,000	6	5.8
$20,001 – $30,000	6	5.8
$30,001 – $40,000	4	3.8
TOTAL	104	100.0
NO LOST CARGO	125	
LOSS UNKNOWN	26	
TOTAL	255	

*INCLUDES TANK BARGES (INFLAMMABLE AND COMBUSTIBLE CARGOES), CARGO BARGES (DANGEROUS AND HAZARDOUS CARGOES) AND TANK BARGES (DANGEROUS AND HAZARDOUS CARGOES).

SOURCE: A Modal Economic and Safety Analysis of the Transportation of Hazardous Substances in Bulk, Maritime Administration, prepared by Arthur D. Little, Inc., July 1974.

Table IV–25
CALCULATION OF BARGE EXPOSURE MILEAGE AND PER MILE ACCIDENT RATES (1971)

LOCATION		COMMODITY VESSEL TON–MILES	COMMODITY MILES[1]	% TRIPS MADE BY BARGE	TOTAL BARGE MILES	HAZARDOUS BARGE MILES[2]	ACCIDENT RATE PER MILLION MILES
MISSISSIPPI RIVER							
BATON ROUGE –	NEW ORLEANS	10,254,380,498	13,672,507	95	12,988,882	5,824,215	.446
MINNEAPOLIS –	MISSOURI RIVER	10,216,015,882	13,621,355	95	12,940,287	5,802,425	.620
MISSOURI RIVER –	OHIO RIVER	9,211,928,159	12,282,571	98	12,036,920	5,397,354	.593
OHIO RIVER –	BATON ROUGE	52,748,960,517	70,331,947	100	70,331,947	31,536,845	.197
	TOTAL				108,298,036	48,560,839	
GULF INTERCOASTAL WATERWAYS							
MISSISSIPPI RIVER –	SABINE RIVER	9,862,790,805	13,150,388	89	11,703,845	5,248,004	.800
SABINE RIVER –	GALVESTON	2,719,632,166	3,626,176	100	3,626,176	1,625,977	1.476
PENSACOLA –	MOBILE	309,803,593	413,071	89	367,633	164,846	1.220
MOBILE –	NEW ORLEANS	1,918,360,385	2,557,814	100	2,557,814	1,146,924	.524
GALVESTON –	CORPUS CHRISTI	2,014,846,402	2,686,462	83	2,229,763	999,826	2,400
	TOTAL				20,485,231	9,185,578	
ILLINOIS RIVER		6,770,744,240	9,027,659	100	9,027,659	4,048,002	.099
OHIO RIVER		30,905,484,849	41,207,313	99	40,795,240	18,292,586	.241
TENNESSEE RIVER		3,960,491,547	5,280,655	100	5,280,655	2,367,846	.338
COLUMBIA AND LOWER WILLIAMETTE RIVERS BELOW VANCOUVER AND PORTLAND		1,815,556,012	2,420,741	83	2,009,215	900,932	.222
	TOTAL				185,896,036	83,355,783	.417

1. AVERAGE TONS PER [illegible] = 750
2. PERCENT HAZARDOUS = 45%

SOURCE: A Modal Economic and Safety Analysis of the Transportation of Hazardous Substances in Bulk, Maritime Administration, prepared by Arthur D. Little, Inc., July 1974.

high as 20,000 years as shown in Table IV-26. These calculated recurrence intervals provide an estimate of the relative risk associated with barge movements of the ten chemicals.

E. POTENTIAL ECONOMIC IMPACTS

Economic impacts resulting from spills and accidents in the waterborne shipment of bulk liquids has caused small to major economic losses as a result of petroleum, gas and chemical spills and incidents. In areas where waterborne commerce is routinely conducted, the role of the waterway is intrinsic to the communities economic viability; therefore when a spill occurs, economic losses are incurred within the immediate spill area and throughout the far field economy area. The principal actual and potential economic losses of a spill are summarized in Table IV-27. This table indicates the complexity of the economic impacts which could be generated from a spill incident at: dockside, within a harbor inland waterway system; or out along the coastal and open ocean trade routes. The economic variability of a spill will range from the simple loss of the cargo as a result of an operational error where no clean up or vessel repairs are required, to a complex incident which will entail all, or the majority, of the principal economic losses itemized in Table IV-27.

Recent incidents involving these complex economic losses were the Sansinana explosion and spill in Los Angeles Harbor (9 killed, 50 injured) and the tanker collision and spills at a Philadelphia refinery on the Delaware River. In both of these cases the major economic impacts will not be determined until the legal settlements are judged. For the less intrinsic loss of marine resources the economic losses will never be fully reconciled.

With the increase in shipment sizes and the hazardous nature of certain cargo probable accident scenarios have been developed which could conceivably produce economic losses in approaching and in excess of one billion dollars. Also, because of the wide variability of economic losses each transportation scheme must be reviewed individually and the potential economic losses and hazards judged accordingly.

Table IV–26
EXPECTED ANNUAL SPILL RATES FOR THE TEN CASE STUDIES FOR BARGE TRANSPORTATION

CHEMICAL	NUMBER OF ANNUAL TRIPS	EXPECTED ACCIDENTS PER TRIP (X 10^4)	EXPECTED ANNUAL ACCIDENTS	EXPECTED ANNUAL ACCIDENTAL SPILL*	NUMBER OF SPILLS, ACCIDENTS / 1,000 TRIPS
ACRYLONITRILE	40	6.52	.0261	.0117	.290
METHANOL	175	5.91	.1034	.0465	.260
STYRENE	100	6.60	.0660	.029	.290
ANHYDROUS AMMONIA	50	2.93	.01465	.0065	.130
CHLORINE	13	.182	.00023	.00011	.008
SULFURIC ACID	18.5	0.04	.00007	.00003	.003
CAUSTIC SODA	43	4.81	.0206	.0092	.213
BENZENE	67	0.38	.0025	.0011	.016
ETHYLENE GLYCOL	50	0.79	.0040	.0018	.036
SUGAR	46	3.32	.015	.0066	.143

* BASED ON SPILL PROBABILITY PER ACCIDENT = 45%. SINCE THE TANK CONSTRUCTION OF CHLORINE AND AMMONIA BARGES IS SUPERIOR TO THE "AVERAGE" TANK BARGES (TO WHICH THE 45% NUMBER APPLIES), THE PROBABILITY OF A SPILL FOR THESE TWO CHEMICALS IS PROBABLY LESS THAN SHOWN.

SOURCE: A Modal Economic and Safety Analysis of the Transportation of Hazardous Substances in Bulk, Maritime Administration, prepared by Aurthur D. Little, Inc., July 1974.

Table IV–27
PRINCIPAL, ACTUAL, AND POTENTIAL ECONOMIC LOSS RESULTING FROM WATERBORNE SPILLS

VESSEL ASSOCIATED LOSSES
1. LOSS OF CARGO 2. LOSS OF VESSEL AND REPAIR 3. LOSS OF FUTURE BUSINESS 4. COST OF VESSEL CLEAN-UP
MUNICIPAL AND COMMERCIAL LOSSES
1. CREATION OF HAZARDS AND DESCRIPTION OF SHIPPING 2. DESTRUCTION OF WATERFRONT AND INLAND FACILITIES AND PROPERTIES CAUSED BY THE INCIDENT 3. PROPERTY VALUE DECLINES 4. POTENTIAL FATALITIES 5. FEDERAL, STATE, AND MUNICIPAL RESOURCES EXPENDED DURING EMERGENCY INCIDENTS 6. LOSS OF RETAIL TRADE 7. WATER SUPPLY IMPACTS AND SHUTDOWNS 8. COST OF SPILL CONTAINMENT AND CLEAN-UP
TOURISM, AMENITY LOSSES
1. BEACH ACTIVITIES 2. SPORT FISHING AND HUNTING 3. BOATING ACTIVITIES 4. CAMPING 5. LODGING AND EATING
COMMERCIAL, AQUATIC AND MARINE RESOURCES, LOSSES
1. SPORT FISH 2. COMMERCIAL FISH 3. SHELLFISH 4. MAMMALS 5. DUCK AND GEESE

SOURCE: Ecology and Environment, Inc., 1978.

F. OTHER SHIP GENERATED POLLUTANTS

Marine pollution has been defined by the 1972 United Nations Conference on the Human Environment as the introduction by man, directly or indirectly, of substances or energy into the marine environment resulting in such deleterious effects as harm to living resources, hazards to human health, hinderance to marine activities including fishing, impairment of quality for use of sea water, and reduction of amenities. Impacts on the aquatic and marine environment from the Domestic Tank Vessel Title XI Program, as defined under marine pollution, are generated by sewage, domestic wastewater, garbage, noise, and stack exhaust. Barges themselves do not generate these types of pollutants, rather the tugs that push them may. Figure IV-16 presents a summary matrix of the vessel generated pollutants from tankships and tank barges and indicates the level of impact each pollutant has on the environment.

1. SEWAGE AND GRAY WATER

Current information concerning the treatment and disposal of vessel sanitary wastes is provided in "Treatment and Disposal of Vessel Sanitary Wastes - A Synthesis of Current Information" (90). For the purpose of this statement the following definitions hold:

- Sewage - human body wastes and the wastes from toilets and other receptacles intended to receive or retain body wastes (35 gallons/man/day);
- Domestic Wastewater (i.e., gray water) - wastes from sinks showers, laundries, and galleys (35 gallons/man/day);
- Sanitary Wastewater - sewage and domestic wastewater (70 gallons/man/day).

It is recognized that even though untreated sewage and gray water from merchant ships is not the chief contribution of the sewage contamination of our waterways, it is certainly additive to pollution from communities along these waterways and has posed a problem in harbor areas prior to recent control regulations. The present EPA regulations, which are reinforced by the Maritime Administration ship construction specifications, do not permit the disposal in certain areas of U.S. waterways of inadequately treated sewage and gray water from vessels. Under the authority of the Federal Water Quality Improvement Act (Section 13) of

TANK VESSEL TYPE	POLLUTANTS								
	OIL CARGO	CHEMICAL CARGO	BILGE OIL	SEWAGE	GARBAGE	DOMESTIC WASTEWATER	STACK EXHAUST EMISSION	CARGO VAPOR VENTING	NOISE
TANK SHIP									
OIL TANKER	●		O	O	O	O	O	●	O
CHEMICAL TANKER		●	O	O	O	O	O	●	O
TANK BARGE									
OIL BARGE	●							●	
CHEMICAL BARGE		●						●	

KEY: ● MAY HAVE SIGNIFICANT IMPACT

O USUALLY INSIGNIFICANT IMPACT

Figure IV–16 SUMMARY MATRIX OF TANK VESSEL TYPE VERSUS POLLUTANTS

SOURCE: Ecology and Environment, Inc., 1978.

1970, the Environmental Protection Agency established standards (Federal Register, June 23, 1972) of performance for marine sanitation devices to prevent the discharge of treated or untreated sewage into or upon the navigable waters of the United States from vessels. Essentially this was a no discharge standard, and new vessels were required to have holding tanks or closed packaged shipboard sewage treatment plants. In 1976 the EPA issued its final standards of performance which, in essence, amend the prior standards and allows under certain conditions the use of flow through sewage treatment plants.

In most navigable waters the sewage plant effluent shall not have a fecal coliform bacterial count greater than 1,000 per 100 milliliters and have no visible floating solids. This standard becomes more stringent after 1980.

Research and development is presently being made in the field of shipboard sewage (and sanitary waste) treatment (90). At present, the simplest effective marine sanitation device is the collection, holding and transfer (CHT) system for sewage and gray water. Each CHT system normally consists of a holding tank, non-clog ejection pumps, flushing system, air supply, fittings, valves and controls necessary to store the wastes and to discharge the contents into a system ashore. More advanced systems are being developed, however. The CHT system permits the discharge of wastes to shoreside facilities for subsequent treatment and disposal. Section 70 of the Marad Standard Specifications for Merchant Ship Construction requires either a sufficiently sized holding tank and CHT system or the installation of certified shipboard sewage treatment plant (91).

2. GARBAGE

Operating vessels daily produce small quantities of garbage and solid waste materials. Although aesthetically unpleasant, over-board discharge of biodegradable garbage in the amount normally produced by vessels in the open ocean is not considered hazardous to the environment and may in fact be beneficial to a certain extent by providing additional nutrients to an area where normal low nutrient levels may be limiting abundant phytoplankton growth.

In port, on the other hand, local ordinances usually forbid garbage being dumped overboard. Consequently, the garbage and trash are either collected for disposal ashore, or they are contained aboard ship for overboard discharge after the vessel puts to sea. Traditionally, Marad has subsidized the installation of garbage grinders and, in addition, is considering the possibility of treatment of the effluent in combination with sewage treatment or removal by incineration.

3. AIR POLLUTION

Vessels transporting bulk liquid petroleum, chemicals and gases represent complex sources of air pollutants. This complexity is attributed to the mobility of the vessel creating a non-point air pollutant source while underway and a point source at dockside and secondly, the great variability of producing air pollutants from cargo transport, storage and transfer operations. The sources of air pollutants from vessel operations are listed in Table IV-28 to illustrate the complexity of the source functions. The principal pollutants which must be reviewed for the general operations are Hydrocarbons (HC), Particulates (Pa), Sulphur dioxide (SO_2), nitrous oxide (NO_2), carbon monoxide $(C)_2$), and other noxious and hazardous air pollutants from substances which may be carried as cargo. The vessel operations air emissions would be different for each phase of the operation but would not be dependent upon the cargo characteristics. The air emissions from the cargo element are dependent upon the specific cargo characteristics and this would change from one petroleum product to another and it would drastically change when gases and chemicals are transported.

As discussed in the water pollutant section there have been many cargo classification studies conducted to determine the potential cargo hazards and to design the appropriate containment vessels and operational procedures to control the potential air pollutant hazards from the materials. In comparison to the vessel generated air pollutants, the potential emission of hazardous and toxic cargo air pollutants represents a much more serious threat to human life and environment resources. A study conducted for the Department of Transportation indicated that

Table IV–28
VESSEL AIR POLLUTANT SOURCES

SOURCE	MOVING POINT SOURCE	STATIONARY POINT SOURCE
TANKER*		
TANKER ENGINES UNDER POWER	X	
TANKER ENGINES LOADING AND UNLOADING		X
TANKER ENGINES HOTELING		X
TUG		
TUG ENGINES UNDER POWER	X	X
TUG ENGINES HOTELING		X
CARGO OPERATION**		
CARGO VENTING DURING UNLOADING		X
CARGO VENTING DURING LOADING		X
CARGO STANDING STORAGE AND TRANSPORT	X	X
BALLASTING OPERATIONS	X	X
PUMP AND VALVE LOSSES		X
TANK CLEANING	X	X

* EMISSION FACTORS ARE FUEL SPECIFIC, HOTELING IS DEFINED HERE AS A VESSEL AT BERTH NOT HANDLING CARGO NOR BUNKERING

** EMISSION & HAZARD FACTORS ARE CARGO SPECIFIC

SOURCE: Ecology and Environment, Inc. 1978.

serious numbers of deaths and injuries could potentially result from air pollution incidents from waterborne cargo spillages.

The control of cargo vapor emissions from safety, health and environment viewpoints has always been an important area of vessel construction. With the great diversity of bulk liquid chemicals which transported on vessels, specific ship design requirements and regulations are being made to insure cargo and crew safety.

4. STACK EXHAUST EMISSIONS

Vessel air pollution produced from the exhaust gases required to operate the vessels are from two principal types of power plants. These are oil fired steam generating facilities which are generally the major propulsion power plant on all Great Lakes and ocean going vessels, and diesel engines as found on all tugs propulsion plants and for auxiliary power requirements. The size on larger vessels of the respective power plants are a function of the vessels size and design. The operating characteristics of a diesel engine require higher fuel grade requirements; consequently, they can be considered to use one fuel type. In contrast, oil fired steam plants use a variety of fuel oils depending upon availability, cost, operating characteristics and air pollution constraints. Air pollution resulting from these different fuels is generally higher than from the less expensive refined products which have a higher sulphur and asphalt content.

Shipboard stack exhaust emissions on steam-propelled vessels are manageable with improvements in fuel and better control over combustion. Fuel additives can be introduced to assist in the combustion process; and the use of certain techniques in boiler firings, such as low excess air combustion, could result in more efficient combustion, particularly at the lower firing rates used in port.

When the oil fired boilers on steam-propelled vessels operate at Low firing rates, soot (particulates) may accumulate on the boiler tubes and uptakes. After a protracted stay in port, it may become necessary to operate the boiler soot blowers in order to prevent soot fires in the

boiler casing and uptakes. However, since the new ships are generally designed for short turn-around time, their port operation will not require soot blowing. Diesel-propelled ships, tugs and gas turbine ships generate exhaust gases which usually contain smaller quantities of soot than steamships.

On diesel engines there is very little emission control after the engine has been adjusted for the most efficient operation. Oil fired steam power plants on the other hand can be drastically controlled by the air and fuel settings and the fuel type. With the increased state and federal controls vessel operators are being required to adjust channel and harbor operations to utilize lower pollutant fuels and make the necessary boiler adjustments to reduce emissions. Lower pollutant fuels generally have a lower sulphur content and produce a more efficient burning process.

It is difficult to assess accurately the impact of exhaust emissions from ships in a metropolitan harbor as, for example, New York City. However, it is generally assumed that the pollution load from vessels in a metropolitan area is substantially lower than that from other sources such as stationary power-generating plants, industry, and automobiles ashore (92). Data from a recent DOT Transportation System Center Study indicate that marine shipping industry is not a significant contributor to air pollution (93). Ships in port areas are required by most existing municipal codes to conform to the local regulations on stack emissions which are enforced by the local agencies.

EPA regulation development pertaining to Section III of the Clean Air Act address the emission of shore facility stack gases for various industry plants including those relating to steam generating plants. While these regulations would apply to shipyard facilities, they would not apply to ships because they are not fixed installations. Provisions of Section 70 of the Standard Specification for Merchant Ship Construction recommend the installation of smoke indicators and alarms.

Concerning the situation in various U.S. ports, it is clear that strictly enforced local ordinances should reduce the overall environmental impact of stack emissions in port areas. If any overriding EPA regulations are implemented, conformance to them will also be required. However, data developed by EPA (94) indicate that underway emissions by both steam and motor vessels and in-berth emissions by steam vessels of carbon monoxide and hydrocarbons are insignificant.

5. NOISE

Vessels generate noise in their operation primarily from their whistles, from the operation of diesel engines and gas turbine drives, and from other machinery such as pumps and winches. With the exception of the noise from whistles, these sounds are limited to the vicinity of the vessel and are of a relatively low level, being muffled by the structure of the vessel itself. Since vessels generally operate in established harbor areas, which are industrial in nature, and since the approaches to these harbors are such that a distance is maintained between the vessel and populated areas, external noises of vessels have not been considered a problem. Some consider vessel noises, such as whistles, as adding to the local color of waterfront and coastal areas. The Noise Control Act of 1972 empowers the Administrator of EPA to set noise emission standards; tank vessels will comply with these standards when they are issued. However, noise pollution from vessels is considered to be insignificant (95).

The Marad Standard Specification for Merchant Ship Construction, Section I, Article 11, provides for shipboard sound insulation and isolation treatment as necessary to keep noise levels within practical limits. Maximum noise levels are stated in the Specification and range from 72 decibels in living spaces to 90 decibels in machinery spaces. The permissible airborne noise levels aboard ship are not to exceed the decibel values given in Table IV-29. These values are consistent with Walsh-Healy Labor Standards. To assure that these standards are maintained during the life of the ship, the U.S. Coast Guard enforces maintenance of engine room noise levels within regulated tolerances.

Table IV–29
MAXIMUM PERMISSIBLE AIRBORNE NOISE LEVELS ABOARD SHIP
(Decibel values)

	FREQUENCY BAND, HZ							
	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
LIVING SPACES	72	66	60	55	52	50	48	47
PASSAGEWAYS	75	69	64	59	57	55	53	52
MACHINERY SPACES	85	85	85	85	85	85	85	85

NOISE MEASUREMENTS SHALL BE TAKEN WITH THE SHIP IN OPERATION AT ABS HORSEPOWER AND WITH NORMAL AUXILIARIES INCLUDING REFRIGERATION, VENTILATION AND AIR CONDITIONING IN OPERATION. MACHINERY SPACE NOISE MEASUREMENTS SHALL BE TAKEN AT THE NORMALLY ATTENDED OPERATING STATIONS AND NOT EXCEED 85 dB(A).

SOURCE: MarAd Standard Specifications for Tanker Construction.

G. TANK VESSEL CONSTRUCTION, REPAIR AND SCRAPPING

1. GENERAL

While this section concerns the construction and general operation of vessels engaged in bulk liquid transport, the vessel generated pollution described herein would be associated with the construction of any type of vessel. The functions can be categorized as: expansion of shipbuilding facilities to accommodate the program; actual construction of the ships; and use of materials.

2. EXPANSION OF FACILITIES

Although the Title XI Program aids in promoting vessel construction, the small amount of the fleet that actually benefits from the Program would not be expected to promote major shipyard expansions. The available shipbuilding capacity is believed to be adequate for the Title XI Program. However, should expansion be required, a few of the salient impacts are discussed herein.

Before shipyard expansion or construction can commence, the project may be subjected to extensive review by the U.S. Army Corps of Engineers and state and local authorities and open hearings are conducted for the public. Environmental Impact Statements may be prepared for each shipyard improvement and specific attention to the environmental setting of the improvement will be required.

Expansion of existing shipyards, which are in most cases located in already highly industrialized areas of a waterfront, will generally require certain disruption of the adjacent shoreline. Such disruptions may be caused by filling, dredging, pile driving, excavation, bottom stabilization, and/or other hydraulic works depending upon the nature of the expansion.

When suitable land area adjacent to the existing facility is not available due to the configuration of the shoreline, location of other industrial plants, proximity of residential sections, or for other reasons,

then such land must be created by filling suitable sections of the waterway on which the expansion is contemplated.

Creation of new acreage by filling an existing waterway, whether for expansion of a shipyard or building a new one, causes permanent impacts on the waterway. The filled bottom ceases to provide natural habitat and possible spawning grounds for marine life. Construction of a new shipyard on land which requires little or no filling would, however eliminate the former terrestrial or wetland environment.

The disturbance to the environment caused by filling, pile driving, and other hydraulic activities will be of a permanent nature, changing the physical environment, and hence, also the associated biota.

3. POLLUTION FROM TANK VESSEL CONSTRUCTION

Shipbuilding like any other major industry generates noise, air, water and solid waste pollutants which must be treated and controlled. A modern shipyard is composed of many operations all of which produce waste streams and airborne emissions from their individual operations. The major operations within the shipyard are: (a) buildings which house steel preparation and manufacturing equipment, i.e., flat and curved steel panel shops and ships for processing special steel shapes; (b) machine shop, pipe shop, electrical, paint, welding metal processing and sheet metal shop; (c) outside storage space in which steel plates are stored; (d) outside plate or other steel assembly areas in which modules or small hull sections are assembled; (e) the shipway or building dock where the hull is erected.

Environmental protection regulations are in force for the pollutant waste streams and airborne emissions from shipyards. These rules and regulations are enforced by federal, state, local and certain authorized commissions in a similar fashion as any industrial source.

Part of the shipbuilding process is done indoors where pollution control can be effectively practiced. The work that is done outside of buildings, in particular, erection of the hull, presents greater problems in abating pollution.

In addition to the U.S. Federal regulations on pollution control in industrial activities, state and local regulations apply to areas in which shipyards are located. While tangible improvements in environmental quality in shipyards have been made, additional steps are being taken as technology in pollution control are developed and as federal, state, and regional guidelines are formulated.

Four principal types of pollution are identified with the shipbuilding industry: air pollution, water pollution, land pollution, and noise pollution.

a. AIR POLLUTION

The sources of air pollution fall into three types: products of combustion, airborne particulates, and airborne fumes and vapors.

(1) Products of Combustion. Combustion products from ships' and yards' boilers and incinerators, smoke from burning and welding operations, exhaust from internal combustion engines, and soot from boiler heating surfaces are combustion products that contribute to air pollution.

To reduce pollution from these sources, the major shipyards report only intermittent use of boilers and in some yards natural gas or low sulfur fuel is used to fire yard boilers. Use of incinerators has been discontinued in favor of having waste removed by licensed disposal firms. Smoke from burning and welding operations and internal combustion engines is generally exhausted to the atmosphere.

(2) Airborne Particulates. Dust resulting from abrasive blasting, dust created by woodworking machinery, and dust due to unpaved roadway surfaces contribute to pollution from airborne particulates.

The problem of airborne particulates from abrasive cleaning is the most difficult to control. The major builders of deep draft ships have installed enclosed abrasive cleaning facilities of major size for cleaning raw stock steel and modular assemblies. Abrasive cleaning and painting of

hulls on the shipways or at outfitting berths is the subject of an intensive industry study. Dust collecting systems have been installed in some of the yards for collection of woodworking dust.

(3) Airborne Fumes and Vapors. Overspray of protective coatings, evaporation of toxic chemicals and solvents, leakage of toxic or explosive gases in piping, fuel tank venting of explosive vapors, odors from sanitary facilities, and photochemically reactive hydrocarbons in paints and solvents are among shipyard airborne fumes and vapors.

The problem of overspray of painting that is done on the shipways or outfitting berths is under study along with abrasive blasting. Airless spraying equipment is used as much as possible. Regularly scheduled tests are made in pipelines for toxic or explosive gases. Flame arrestors and stops are installed in fuel tank vent lines.

b. WATER POLLUTION

The basic types of discharge that could emanate from shipyards and pollute the waterways fall into two broad categories: liquids and solids.

(1). Liquids. Liquids include chemical make-up plus suspended solids and thermal change. Sanitary waste discharges, discharge of process chemicals, petroleum spills, overflow, and leakage; overspray and spillage of protective coatings; and discharge of cleaning fluids are among the liquids that contribute to water pollution. Sanitary waste discharges are disposed of through municipal sewer systems. Collection of process chemicals and cleaning fluids for removal by outside contractors is practiced by the major shipbuilders. Oil spill crafts with booms and other procedures are in use to handle accidental oil spills. Paint overspray and spillage have been minimized by the use of airless spray equipment and rollers.

(2). Solids. Overboard discharge of spent abrasives, waste and scrap materials, debris from launching ways or deteriorated waterfront structures, and disposal of dredging spoils are among the solids that contribute to water pollution.

Shipbuilders enforce strict regulations on controlling the discharge of spent materials, i.e., grit, rust, scale, and paint residues into the waterways. In the vessel construction process most of the blasting is done indoors under controlled conditions. Building docks and shipways are cleaned after the blasting operation and in some of the yards abrasive material is reclaimed.

Overboard discharge of waste or scrap materials is against shipyard policy. Debris from launching ways is retrieved by yard water patrols. This is primarily a function of launching a ship. Disposal of dredging spoils is controlled by the Corps of Engineers through the designation of dumping sites.

c. SOLID WASTE AND OTHER POLLUTION

Solid waste and other pollution sources include a broad variety of materials used in the various shipbuilding processes and operations. Grit, rust, scale, metal and paint chips from abrasive cleaning of steel on shipways and outfitting berths are difficult to control. As previously noted, this problem is the subject of a cooperative industry study.

Petroleum spills from fuel handling and storage and machinery operations; metallic residues from welding and brazing operations; paint residues from coating processes; solvent spills from cleaning operations; metal scraps and particles from flamecutting operations; sand and resin dust from casting operations and chemical spills from galvanizing all contribute to this pollution. The major shipbuilders have installed devices and methods to abate much of the pollution from these sources.

d. NOISE POLLUTION

The major noise pollutant sources in shipbuilding have been identified as diesel and gas power source exhausts, high capacity vent fans, percussion tools and air operated tools. The industry is combating noise through the use of mufflers, silencers, equipment modifications, incorporation of noise standards in specifications for equipment and restricted

use of horns and whistles.

4. USE OF MATERIALS

Vessels are built primarily of steel. Steel is used in the vessel hull, machinery, pipeline and almost all the other systems and comprise approximately 96 percent of the vessel weight. The second most important material used in vessel construction is copper, which is used in the propeller and electrical systems. The remainder of the vessel uses small amounts of a large number of materials as shown on Table IV-30.

The analysis of material used in shipbuilding is that it utilizes 0.25 to 0.5 percent of the nation's production of steel and copper products. The environmental impact as far as material is concerned would be in proportion to that accorded to the steel and copper industry.

5. VESSEL REPAIR

Because of casualties and the need for routine maintenance and inspection, a vessel spends a yearly average of 10 days in a ship repair yard. During this lay up period routine maintenance and major repairs are performed. Barges which enter the repair yard for hull related repairs and inspection, generally spend about 5 days per year in the yard.

To meet this need, an extensive vessel repair industry has developed in nearly every U.S. port. The industry includes both small, "topside" shops which have the capability to repair and overhaul machinery, and vessel construction yards which have the capability to drydock vessels and perform hull repair work.

In essence, the pollutants generated by ship repair operations are the same as those created in the shipbuilding process. These fall into the following categories:

Table IV–30
MATERIALS USED IN SHIP AND BARGE CONSTRUCTION

ACETYLENE	MANGANESE (CASTING)
ALUMINUM	MERCURY
ASBESTOS	NICKEL
ASPHALT	NITROGEN
CARBON DIOXIDE	PAINTS
CEMENT	PAPER
CERAMICS	PETROLEUM
CHEMICALS (ACETONE, ALCOHOL, AMMONIA, CREOSOTE, GLYCERIN)	PHARMACEUTICALS
CHROMIUM	PLATINUM
CLAY	RARE EARTH
CLEANING COMPOUNDS	REFRIGERANT (CHLORINE, FLOURINE)
COPPER	RUBBER
CORDAGE	SILICON
DIATOMACEOUS EARTH	STEEL
FIBER GLASS	TALLOW
GLASS	TAR
HELIUM	TEXTILES
LEAD	TITANIUM
MAGNESIUM	WOOD
	WOOL
	ZINC

SOURCE: U.S. Department of Commerce, Maritime Administration, NTIS Report NO. EIS 7300727F, Final Environmental Impact Statement, Maritime Administration Tanker Construction Program, May 30, 1973.

a. AIR POLLUTION

- Combustion products, including internal combustion engine exhausts, welding and burning, and boiler operations:
- Particulates resulting from blasting and painting;
- Fumes and vapors resulting from evaporation of paint solvents, fuel tank venting, and refuse and sanitary odors.

b. WATER POLLUTION

- Overboard discharges of spent chemicals, sanitary wastes, and refuse and trash.

c. NOISE POLLUTION

- Sounds of mechanical equipment in operation;
- Horns, whistles, air operated percussion tools, etc.;
- Rapid expansion of gases.

Although there are no statistics available to Marad that indicate the volume of specific pollutants generated in the vessel repair and conversion process, it is reasonable to assume that there will be no new pollutants, above those already listed. More likely, the volume and mix of specific pollutants will be altered.

Because of better equipment and longer-lived coatings, the new vessels do not require as much maintenance and repair work as older vessels.

6. SCRAPPING

A vessel is scrapped at the end of it's useful life, (i.e., approximately 20 to 25 years for a tanker and 25 years for a barge). In this process, a shipbreaker dismantles the vessel in approximately the reverse order of its construction.

This process involves cutting the vessel and its components up with torches and removing reusable equipment and parts. The following types of pollutants are generated:

- Fumes and vapors resulting from the use of acetylene torches and other cutting devices;
- Unrecoverable wastes, such as lumber, insulating materials, and concrete ballast;
- Sanitary wastes;
- Fuel, diesel oils, and greases.

Both ferrous and non-ferrous metals are recovered from the vessel and sold to producers who recycle them.

There are no records of the volume of pollutants produced in the scrapping process; however, these are monitored and required to meet local and Environmental Protection Agency air and water pollution standards.

The recovery of both ferrous and non-ferrous metals during recycling results in a significant saving of natural resources and the efforts to minimize the volume of pollutants produced in the scrapping process justified in the light of the overall savings realized.

H. PORT, HARBOR AND WATERWAY DEVELOPMENT

Although Title XI does not directly promote port and harbor development it does so by indirectly promoting waterborne commerce in lieu of overland rail, truck and pipeline modes of transport. An example is the new Alaskan-Valdez port development and expansion of southern California port facilities to transport the Alaskan crude, versus the construction of an overland pipeline into the mid U.S. (like the proposed ALCAN natural gas pipeline). In order to determine what, if any, port and related development can be expected to take place consideration must first be given to ports and related facilities and their ability to handle Program vessels.

Conventional port or terminal facilities are those assigned to handle the trade which is normal in volume and character to the geographic area served by the facility. These conventional ports can be divided into several categories such as:

1. EXCAVATED HARBORS

As a result of the relative inflexibility of excavated harbors to accommodate future changes, accurate long-haul forecasting of the facility purpose and capacity is a necessity, when compared to a substantial investment in breakwaters and dredging. The breakwaters generally disturb the ecological balance causing coastal erosion and sand transport, and limited flushing requires special attention to effluents and basin cleaning. On the plus side, such man-made harbors may help develop an otherwise unproductive or economically depressed area which lacks estuaries or natural bays. The waterfront is small, and basins are well protected with reduced maintenance and dredging. However, in the United States, there are numerous natural harbors which could be developed if such are required.

2. LOCKED BASINS

As in the case with excavated harbors, locked basins are inflexible to changes.

3. TIDAL BASINS

These basins are of a more flexible nature, but the inconvenience of vertical movement during cargo handling is reduced by the increased size of modern vessels.

4. RIVER AND ESTUARY PORTS

These type ports enable maritime traffic to move far into the hinterland thereby bringing the cargo closer to consuming centers which can result in substantial transportation cost savings.

Except, possibly those vessels used in the Alaskan trade, most of the vessels covered by this EIS should be able to enter many of the U.S. ports without any additional dredging.

However, in the event that additional vessel traffic would require some alteration or addition to the current facilities, environmental impact statements would be required by the U.S. Army Corps of Engineers before a permit to build in navigable waters is issued. In addition, the United States Coast Guard would require certain environmental protection actions pursuant to the provisions of the Federal Water Pollution Control Act, amended in 1972, and the Ports and Waterways Safety Act of 1972. An example of this process is the Trans Alaska Pipeline System Terminal at Valdez, Alaska which underwent a federal and state environmental review.

The environmental impacts of shore facility development associated with ports and waterways deal primarily with land use, water, and air pollution problems. The problems will vary from one alternative to another, depending upon a number of factors. The five principal factors, or dimensions, which combine to dictate the impacts are:

- Whether the site or waterway selected is a new one or an existing one.
- Whether the principal development is onshore or offshore or along an existing waterway.
- Whether the waterway facility is for transfer only or is also planned for processing and other secondary developments.
- The type or types of bulk commodity that will move through the waterway, pollutant streams and hazards.
- The type and value of the aquatic, marine, estuarine and terrestrial ecosystems disturbed by the proposed system.

5. PORT AND HARBOR DEVELOPMENT

Each component of the given port or waterway system will have certain design characteristics that will determine how existing and planned land use will be affected. In the context of the delivery system, the shore facility problem starts with the point of loading/unloading and is a factor in each component through the processing. Berths, docks and bulkheads will alter a hitherto undeveloped area substantially, especially where there are important wetlands, beaches, or riverbank areas.

Other areas previously in use as a port, or navigable waterway which are changed to accommodate these vessels may have little or no impact in cases where the existing waterfront is in a state of decay.

If the site is an existing port, there may be a need for expanded channel and turning basins, and land storage areas. Finding storage space may be a significant problem in a heavily developed area. It could well mean the displacement of other land uses and will have to be evaluated on an individual basis.

The impact of constructing a new dock facility in a previously underdeveloped area will create greater environmental and land use problems. The site will probably be selected so that space is not a problem; however, the visual aspects, air, and water pollution problems generated may be very significant and controversial. In new development there is also the opportunity to select sites which will result in a minimum of environmental intrusion by avoiding ecologically sensitive areas and by placing structures inland from the shoreline.

A final element in the analysis of shore facilities is the development of auxiliary facilities and associated secondary development. This can have more significant environmental impact than any other component of a port system over a long period of time. Auxiliary processing facilities and secondary development themselves frequently use large pollution and solid waste disposal problems, create significant visual intrusions place demands upon local water supplies, and if successful, create employment through the multiplier effects which would increase population and the subsequent demand for housing and services such as roads, sewers and schools.

For the Washington State the shipbuilding economic multiplier has been calculated to be 2.90. This value would be expected to be fairly representative for the industry on a national basis.

If the area of the port is already heavily developed, such new growth can create congestion that places burdens on existing utilities and services. Development in a new area can take these problems into

account through proper site selection, design and planning; but there is no automatic guarantee that this will happen. In fact, it is likely not to happen in a satisfactory way unless these factors are specifically taken into account during the planning and design of such a facility.

In any evaluation of the impact of shore facility development, there are two different philosophies which should be recognized and considered. First, there is the point of view that adding new and larger facilities and possibly further water, air and visual pollution to a port site now in use will have less of an impact than the creation of a new port on an unspoiled coastal area. On the other hand, there is the argument that existing port areas are so heavily used and congested that environmental degradation should not be allowed to proceed further and, therefore, that new port development should look to new areas where adequate planning and regulation can maintain an orderly, environmentally acceptable pattern of growth. These are perplexing problems which must be reviewed on an individual basis by all parties under the NEPA process.

In either case there are alternatives for combating environmental problems. Expansion of existing ports can be designed to improve the area. This is especially true where existing port facilities are old, outdated, or no longer in use because of obsolescence. Renovation could substantially improve the total environment of the area and possibly eliminate a potential fire hazard. In totally new locations, the most modern precautions could be taken to preserve the environment.

6. WATERWAY DEVELOPMENT

The development of new waterways and the expansion and modification of existing waterways to promote greater waterborne commerce is controversial with respect to environmental and competing transportation modes and has brought numerous environmental court cases which have attempted to block these developments. The Corps of Engineers has currently authorized navigation extensions on the Trinity, Red Tembigee, and Coosa Rivers and has numerous smaller channel, lock and navigation improvements planned which could be utilized by Title XI vessels.

The Title XI Program is not responsible for promoting these projects other than being considered as a general waterborne industrial statistic. These programs in all cases would be necessary without any Title XI funding to the industry, but this Program can be considered as a small contributor and benefactor of these programs.

The environmental effects of the waterway programs produces permanent changes in land use, aquatic biota, water quality and terrestrial environment within the area of the project. These specific impacts of the project are discussed on an individual basis under NEPA guidelines and will not be discussed herein. The environmental analysis of each individual program is analyzed at the federal, state and local levels through the environmental impact statement process prior to final authorization. In proceeding in this manner each program must be justified on its own merits. In general terms the environmental impacts are similar to those discussed for harbor and port development but of much greater magnitude and complexity because of the extent and linear nature of the system.

CHAPTER IV - REFERENCES

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CHAPTER V

MITIGATING FACTORS

The mitigation of environmental impacts resulting from domestic waterborne commerce is extensive and complex. This complexity is attributed to the nature of the potential impacts which can be generated by the waterborne commerce and the myriad of state, federal and international, legislative actions and agencies which have control of waterborne commerce within their respective jurisdictions. The control of waterborne impacts can be principally divided into: vessel construction and operating requirements, marine transportation services, personnel training, inspection and monitoring, spill control and cleanup, and recent/future programs.

A. VESSEL CONSTRUCTION AND OPERATING REQUIREMENTS

1. OVERVIEW

The construction and operation of tank vessels for the domestic trade are subject to specific standards of the U.S. Coast Guard (USCG), American Bureau of Shipping (ABS), and Environmental Protection Agency (EPA). Table V-1 lists the nucleus of federal regulations dealing with the pollution control provisions on tankers. In addition, the U.S. Maritime Administration has established standards for pollution control equipment for tankers constructed within the United States.

2. U.S. COAST GUARD CONSTRUCTION AND OPERATING REQUIREMENTS

Ship construction regulations administered by the U.S. Coast Guard and its especially impowered agency, the American Bureau of Shipping, govern most facets of ship construction. The Coast Guard, as the principal Federal regulatory agency, promulgates design and construction regulations, reviews designs, and makes inspections during construction and at periodic intervals throughout the vessel's service life.

Table V–1
FEDERAL REGULATIONS ON TANKER POLLUTION CONTROL

TITLE AND SUBCHAPTER	PART	FEDERAL AGENCY
TITLE 33, CODE OF FEDERAL REGULATIONS, SUBCHAPTER O – POLLUTION	PART 151 – OIL POLLUTION REGULATIONS	U.S. COAST GUARD
	PART 153 – CONTROL OF POLLUTION BY OIL AND HAZARDOUS SUBSTANCES, DISCHARGE REMOVAL	
	PART 154 – LARGE OIL TRANSFER FACILITIES	
	PART 155 – VESSEL DESIGN AND OPERATIONS	
	PART 156 – OIL TRANSFER OPERATIONS	
	PART 157 – TANK VESSELS CARRYING OIL	
	PART 159 – MARINE SANITATION REQUIREMENTS, CERTIFICATION PROCEDURES AND DESIGN AND CONSTRUCTION REQUIREMENTS	
SUBCHAPTER P – NAVIGATION	PART 161 – VESSEL TRAFFIC SERVICES	
	PART 164 – NAVIGATION SAFETY REGULATIONS	
TITLE 40, CODE OF FEDERAL REGULATIONS, SUBCHAPTER D – WATER PROGRAMS	PART 100 – DISCHARGE OF OIL	U.S. ENVIRONMENTAL PROTECTION AGENCY
	PART 116 – DESIGNATION OF HAZARDOUS SUBSTANCES	
	PART 117 – DETERMINATION OF REMOVABILITY OF HAZARDOUS SUBSTANCES	
	PART 118 – DETERMINATION OF HARMFUL QUANTITIES FOR HAZARDOUS SUBSTANCES	
	PART 119 – DETERMINATION OF UNITS OF MEASUREMENT AND RATES OF PENALTY FOR HAZARDOUS SUBSTANCES	
	PART 125 – NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)	
	PART 140 – MARINE SANITATION DEVICES, STANDARDS OF PERFORMANCE	

Table V–1 (Cont'd.)

TITLE AND SUBCHAPTER	PART		FEDERAL AGENCY
TITLE 40, CODE OF FEDERAL REGULATIONS, CHAPTER V	PART 1510 –	NATIONAL OIL AND HAZARDOUS SUBSTANCES POLLUTION CONTINGENCY PLAN	COUNCIL ON ENVIRONMENTAL QUALITY
TITLE 46, CODE OF FEDERAL REGULATIONS, SUBCHAPTER D – TANK VESSELS	PART 30 –	GENERAL PROVISIONS	U.S. COAST GUARD
	PART 31 –	INSPECTION AND CERTIFICATION	
	PART 32 –	SPECIAL EQUIPMENT, MACHINERY AND HULL REQUIREMENTS	
	PART 34 –	FIREFIGHTING EQUIPMENT	
	PART 35 –	OPERATIONS	
	PART 36 –	ELEVATED TEMPERATURE CARGOES	
	PART 38 –	LIQUEFIED FLAMMABLE GASES	
SUBCHAPTER O – CERTAIN BULK DANGEROUS CARGOES	PART 153 –	SELF-PROPELLED VESSELS CARRYING BULK DANGEROUS OR EXTREMELY FLAMMABLE LIQUID CARGOES	
	PART 154 –	SELF PROPELLED VESSELS CARRYING BULK LIQUEFIED GASES	

SOURCE: Code of Federal Regulations

The regulations are designed to make the U.S. vessels the safest vessels in the world merchant fleet and provide the greatest affordable degree of environmental protection. The results of this construction program are clearly demonstrated in the lower number of oil spills by the U.S. fleet in comparison with the foreign flag vessels.

The Coast Guard's design requirements for tank vessels ensure that, even if a vessel sustains damage, it will remain afloat with a minimum or no loss of cargo. To achieve this goal, the Agency prescribes acceptable levels of compartmentation and freeboard for each vessel design, so that damage to one tank, or certain combinations of tanks, will not result in the vessel's sinking.

In regard to chemicals, the Coast Guard certifies all new U.S. vessels for the carriage of bulk danagerous cargoes. For those liquid chemicals, which are not covered by regulations, requirements are made based upon a safety evaluation by the Coast Guard. This evaluation assures that the cargo in question can be safely contained during transport, loading and unloading without pollution effects. Otherwise, Coast Guard ship design approval and cargo certification would be withheld.

The Coast Guard development of procedures and regulations for the safe water transportation of dangerous chemical cargoes is oriented toward changing conditions in water transportation and providing for: (1) the growing size of new multiple-hazards cargoes, (2) advances in cargo containment technology, and (3) increasing waterway and port congestion. The Coast Guard's approach to regulations for dangerous chemical cargo is casualty-preventive. It is based on achieving marine safety by evaluating potential hazards and adopting necessary preventive measures beforehand rather than investigating "after the casualty" to determine what and who is to blame. Regulations to control engineering design and operational procedures with respect to cargo containment, personnel and cargo transfer are implemented in order to protect against hazards which relate to the vessel, crew, public safety and environmental pollution. The safety regulations are designed to protect the public and industry from all cargo hazards. The problems and experiences of industry and government as well as specific research programs form the basis for appropriate safety designs and procedures.

The U.S. Coast Guard has issued regulations for unmanned barges which are engaged in the movement of certain bulk dangerous chemical cargoes (46 CFR 151). These regulations set uniform minimum requirements for unmanned tank barge construction and operation to provide pollution free transportation. The design and construction for cargo containment depends upon the physical, chemical and toxic properties of the cargo. Because of the many possible varying combinations of these properties, a standard procedure cannot be used to determine the design factors of a given cargo system. Therefore, the approach used to evaluate cargo system safety is usually on a case-by-case basis. Cargoes which require the most exacting containment exhibit the following characteristics:

- Highly toxic
- Water insoluble
- Lighter than water
- Highly reactive
- High freezing point
- Low boiling point
- Highly flammable (wide flammability range)
- Pyrophoric

The loss or leakage of cargo can occur because of swamping, collision or sinking of vessels, poor design and construction techniques, and improper operation or maintenance procedures. Also, the chemical cargo could reach and react with or adversely affect the vessel's hull structure, contaminate the voids around the tank, pollute the air and the water, and endanger the crew and the public.

Since our waterways and navigable waters may traverse populated communities this latter concern is a high priority item.

The operational controls of the waterborne commerce industry constitute an important part of the overall mitigation process. The requirements which govern the maritime operations are principally controlled and enforced by the U.S. Coast Guard. Other agencies which have jursidiction over the air, water and solid waste aspects of the waterborne

commerce industry are the Environmental Protection Agency, U.S. Army Corps of Engineers, and the individual state agencies which regulate and enforce the discharge of pollutants to these resources. MarAd under the Title XI Program initially reviews the ability of the vessels and crews to operate within the framework of the federal regulations. After the assistance is granted, the vessel operations would have to conform to U.S. Coast Guard regulations. The daily operations including cargo loadings, pilotage, cargo transfer, shipboard safety, and general shipboard operations are controlled by the U.S. Coast Guard. The Coast Guard is the primary agency responsible for the implementation and enforcement of federal merchant vessel laws pertaining to waterborne safety and pollution abatement. The regulations implemented by the Coast Guard provide for pollution prevention with regard to cargo containment, and transfer operations.

Since prevention is the most acceptable means of maintaining environmental quality, the Coast Guard Pollution Prevention Regulations (33 CFR 154, 155, 156) provide equipment requirements and operating procedures for vessels and terminals. These regulations were developed to reduce the probability of an accidental discharge of oil or oily wastes during normal vessel operation, during the transfer of oil or oily wastes or as a result of certain vessel accidents. Standards for bilge and ballast piping, oil transfer hoses, qualifications for the person-in-charge of an oil transfer, and required tests and records of those tests are in the regulations. These regulations are continually under revision and reflect the latest developments in oil pollution control technology.

3. AMERICAN BUREAU OF SHIPPING RULES

The American Bureau of Shipping (ABS) rules give sound guidance for structural design of vessels. Major classification societies such as ABS base their rules on years of experience and research, and they strive to keep informed of the current state of the art in order to improve their rules. However, during recent years, there have been several polluting incidents by tankers due in part or in total to structural problems of some type.

A change of requirements in four different areas could result in an improvement in pollution abatement caused by structural inadequacies: (1) decrease the permissible scantling reduction for structure with corrosion control coatings, (2) increase side shell plating thickness forward and aft of 0.4L amidships, (3) increase bottom shell plating thickness, and (4) additional survey requirements. The suggested higher requirements could be considered over-design and their potential advantages and disadvantages will have to be studied thoroughly before implementing them.

4. MARITIME ADMINISTRATION SPECIFICATIONS

The Maritime Administration has developed standard specifications to provide guidance for merchant ship designers preparing detailed ship specifications. The ship specifications are divided into over 100 sections, and each section deals with a specific part, system or related series of systems.

The construction guidelines follow the latest requirements for the reduction of pollution to the air, water and land resources. MarAd now recommends the applicable design features and equipment for all Title XI ships. This is especially critical with respect to the pollution abatement provisions of Sections 70 and 94-4 of the MarAd Specifications. The major environmental specifications of Sections 70 and 94-4, presented in Table V-2, are mandatory solely for tankers receiving MarAd construction subsidy assistance and are guidelines for Title XI tank vessels (1,2).

Since its inception, Sections 70 and 94-4 have periodically been updated to prescribe current standards and regulations of the Environmental Protection Agency, the Coast Guard and IMCO. It is the general intent of the MarAd Pollution Abatement Specifications to recommend appropriate pollution control measures for the design, construction and operation of all merchant ships in order to protect the quality of the marine environment from ship-generated pollutants. These provisions include oil water separator, oily water slop tank, oil and sewage shoreside discharge connections, oil content meter, marine sanitation device, segregated ballast, pump emergency shutdown, overflow alarm, smoke indicator and alarms and many other features.

Table V–2
MarAd POLLUTION ABATEMENT SPECIFICATION

SPECIFICATION SECTION	DESCRIPTION OF ITEM
70–1 GENERAL POLLUTION CONTROL MEASURES	(a) IT IS THE GENERAL INTENT OF THIS SECTION TO SPECIFY APPROPRIATE POLLUTION CONTROL MEASURES TO BE TAKEN IN THE DESIGN AND OPERATION OF ALL MERCHANT SHIPS IN ORDER TO PROTECT AND ENHANCE THE QUALITY OF THE MARINE ENVIRONMENT FROM SHIP-GENERATED POLLUTANTS, SUCH AS OIL, SEWAGE, GARBAGE, AND SMOKE. (b) ALL VESSELS SHALL BE SO EQUIPPED AND OPERATED AS TO PREVENT THE DISCHARGE OF OIL INTO OR UPON THE NAVIGABLE WATERS OF THE UNITED STATES, ADJOINING SHORELINES AND WATERS OF THE CONTIGUOUS ZONE IN SUCH QUANTITIES AS TO CAUSE A FILM OR SHEEN UPON OR DISCOLORATION OF THE SURFACE OF THE WATER OR UPON ADJOINING SHORELINES. (c) ALL VESSELS EQUIPPED WITH TOILETS AND URINALS SHALL BE PROVIDED WITH MARINE SANITATION DEVICES DESIGNED TO PREVENT THE DISCHARGE OF UNTREATED OR INADEQUATELY TREATED SEWAGE INTO OR UPON THE NAVIGABLE WATERS OF THE UNITED STATES.
70–2 CARGO OIL TANKS ON TANK VESSELS	(a) SIZE AND ARRANGE CARGO TANKS TO LIMIT OIL OUTFLOW FROM TANKS BREACHED BY COLLISION OR GROUNDING TO A VALUE OF $30{,}000\ m^3$ or 400^3 DWT WHICHEVER IS LARGER, BUT IN NO CASE EXCEEDING $40{,}000\ m^3$.
70–3 CARGO PIPING SYSTEM ON TANK VESSELS	(a) REMOTE SHUTDOWN OF ALL MAIN CARGO PUMPS SHALL BE PROVIDED AT LOADING AND DISCHARGE MANIFOLD ON THE DECK P&S, AND AT THE CENTRALIZED CONTROL STATION. (b) QUICK CLOSING VALVES WITH MEANS FOR LOCAL CONTROL SHALL BE FITTED AT THE LOADING AND DISCHARGE MANIFOLD. (c) TO REDUCE THE CALCULATED OUTFLOW DUE TO GROUNDING, AN EMERGENCY CARGO TRANSFER SYSTEM MAY BE INSTALLED. (d) CONTAINMENT AROUND EACH OIL LOADING AND DISCHARGE MANIFOLD AND OIL TRANSFER CONNECTION AREA.
70–4 BILGE BALLAST SYSTEMS AND CARGO/BALLAST SYSTEMS A. GENERAL	(a) ALL BILGE AND BALLAST SYSTEMS SHALL BE SO ARRANGED AS TO ASSURE THAT ALL OILY BILGE OR BALLAST WATER WILL BE DISCHARGED EITHER OVERBOARD THROUGH AN APPROVED OILY WATER SEPARATOR, OR DIRECTLY INTO A DESIGNATED SLOP TANK WHICH DECANTS THE EFFLUENT TO 15 ppm OR TO A SHORE BALLAST RECEPTION AND TREATMENT FACILITY. (b) CARGO/BALLAST SYSTEMS ON TANK VESSELS SHALL BE SO ARRANGED TO INSURE THAT OILY BALLAST WATER OR TANK WASHINGS ARE: (1) DECANTED OR DISCHARGED OVERBOARD VIA AN APPROPRIATE OIL CONTENT METER; (2) RETAINED ON BOARD FOR "LOAD-ON-TOP"; OR (3) DISCHARGED ASHORE TO A RECEPTION AND TREATMENT FACILITY.

Table V–2 (Cont'd.)

SPECIFICATION SECTION	DESCRIPTION OF ITEM
70–4 BILGE BALLAST SYSTEMS AND CARGO/BALLAST SYSTEMS A. GENERAL (Cont'd.)	(c) VESSELS SHALL BE FITTED WITH SLOP TANKS HAVING A CAPACITY TO RETAIN ON BOARD ALL OILY WASTES AND OILY BILGE SLOPS THAT MAY ACCUMULATE WHILE OPERATING IN THE NAVIGABLE WATERS OF THE UNITED STATES.
B. GENERAL CARGO VESSELS	(a) 100% SEGREGATED BALLAST SYSTEM SHALL BE PROVIDED. SYSTEM SHALL BE SERVED BY A CLEAN BALLAST PUMP. (b) AT NO TIME SHALL BALLAST WATER BE PLACED IN FUEL TANKS OR CARGO OIL TANKS. (c) REMOTE LIQUID LEVEL INDICATORS SHALL BE PROVIDED AT THE BALLAST CONTROL STATION FOR ALL SEGREGATED BALLAST TANKS.
C. TANK VESSELS	(a) ALL TANK VESSELS SHALL BE DESIGNED TO ALLOW FOR DEBALLASTING AND TANK CLEANING OPERATION BY MEANS OF LOT. THE METHODS SHALL ALLOW THE OILY BALLAST AND TANK WASHINGS TO BE PUMPED TO A SLOP TANK AND DISCHARGED OVERBOARD; SHALL NOT CONTAIN OIL IN EXCESS OF THE MAXIMUM LIMIT PRESCRIBED FOR THE RECEIVING WATER. (b) ALL TANK VESSELS NOT EQUIPPED TO HANDLE DEBALLASTING AND TANK CLEANING OPERATIONS BY THE LOAD-ON-TOP METHOD SHALL BE DESIGNED FOR SEGREGATED BALLAST OPERATION. (c) ALTERNATIVELY, AN EFFECTIVE OIL/WATER SEPARATOR SYSTEM OF FULL FLOW CAPACITY EQUIVALENT TO AT LEAST ONE MAIN CARGO OIL PUMP SHALL BE INSTALLED WITH AUTOMATIC SHUT-DOWN OF EFFLUENT WHEN THE OIL CONTENT EXCEEDS 15 ppm.
D. OILY WATER SEPARATORS	(a) APPROVED SEPARATORS INSTALLED IN THE BILGE AND BALLAST SYSTEM SHALL BE CAPABLE OF PRODUCING AN EFFLUENT CONTAINING NO MORE THAN 15 ppm.
E. OIL CONTENT METERS (ALSO 58–8)	(a) AN OIL CONTENT METER SHALL BE INSTALLED IN EACH BILGE AND OILY BALLAST OVERBOARD DISCHARGE LINE. THE OIL CONTENT METER SHALL BE FITTED WITH AN ALARM DEVICE SET TO OPERATE AT A PRE-SET VALUE TO SHUT-DOWN THE PUMP OR AN APPROPRIATE VALVE IN THE DISCHARGE LINE AUTOMATICALLY WHEN THE OIL CONTENT IN THE OVERBOARD DISCHARGE EXCEEDS 15 ppm.
F. SHORE CONNECTION	(a) DISCHARGE STATIONS SHALL BE FITTED FOR THE BILGE AND BALLAST SYSTEM ON THE MAIN DECK, PORT AND STARBOARD, TO ENABLE OILY BILGE AND BALLAST WATER TO BE PIPED TO SHORE FACILITIES. EACH DISCHARGE STATION SHALL BE FITTED WITH A 5" INTERNATIONAL STANDARD SHORE CONNECTION AND A BLIND FLANGE.

Table V–2 (Cont'd.)

SPECIFICATION SECTION	DESCRIPTION OF ITEM
70–4 BILGE BALLAST SYSTEMS AND CARGO BALLAST SYSTEMS G. OVERBOARD DISCHARGE PIPING	(a) OVERBOARD DISCHARGE PIPING FROM OILY/WATER SEPARATORS AND LOAD-ON-TOP OPERATION SHALL BE FITTED WITH AT LEAST TWO SHUT-OFF VALVES AS CLOSE TO THE SHELL AS POSSIBLE.
70–5 FUEL OIL SYSTEM	(a) ALL OVERFLOW PIPING IN THE FUEL OIL SYSTEM DISCHARGING OVERBOARD SHALL BE FITTED WITH AN ALARM WITH INDICATOR AT THE FILLING STATION AND CONTROL CONSOLE.
70–6 SEWAGE TREATMENT AND LIQUID WASTE DISPOSAL SYSTEMS A. GENERAL	(a) ANY VESSEL EQUIPPED WITH TOILETS, SHOWERS, LAVATORIES, LAUNDRIES OR A GALLEY SHALL BE PROVIDED WITH A SUITABLE MARINE SANITATION SYSTEM CAPABLE OF MEETING THE STANDARDS ESTABLISHED BY THE ENVIRONMENTAL PROTECTION AGENCY, OR ALTERNATIVELY, SUITABLE SIZED HOLDING TANKS SHALL BE PROVIDED TO RETAIN THE SEWAGE AND LIQUID WASTE WHILE IN PORT OR IN RESTRICTED WATERS. ALL MARINE SANITATION DEVICES SHALL BE CERTIFIED BY THE USCG.
B. SEWAGE TREATMENT PLANT	(a) THE DESIGN AND OPERATION OF THE SEWAGE TREATMENT PLANT SHALL MEET THE STANDARDS OF THE ENVIRONMENTAL PROTECTION AGENCY.
C. HOLDING TANKS	(a) WHEN PROVIDED, HOLDING TANKS SHALL BE OF SUFFICIENT CAPACITY TO RETAIN ALL ACCUMULATED URINALS, TOILETS, SHOWERS, LAVATORIES, LAUNDRIES, AND GALLEYS AND SHALL BE CAPABLE OF HOLDING 15,000 GALLONS OF ACCUMULATED SEWAGE AND LIQUID WASTES OR HAVE A FIVE DAY CAPACITY BASED ON THE TOTAL SHIP COMPLEMENT AT 70 GALLONS/DAY/PERSON.
D. PIPING	(a) ALL LIQUID WASTES FROM URINALS, TOILETS, SHOWERS, LAVATORIES AND LAUNDRIES SHALL BE LED TO THE SEWAGE TREATMENT TANK. SEWAGE DRAINS SHALL BE LED TO THE TREATMENT PLANT OR HOLDING TANK INDEPENDENT OF OTHER DRAINS. SHORE CONNECTIONS FITTED WITH 4" PIPE SHALL BE LOCATED ON THE MAIN DECK, PORT AND STARBOARD, TO ENABLE SEWAGE AND LIQUID WASTE TO BE PUMPED TO SHORE FACILITIES.
70–7 STACK EMISSION A. GENERAL	(a) ALL STACK EMISSIONS SHALL MEET THE AIR PURITY STANDARDS ESTABLISHED BY THE PORTS OF CALL OF THE VESSEL, THE STANDARDS OF THE SAN FRANCISCO BAY AREA OR THE STANDARDS OF NEW YORK CITY, WHICHEVER ARE MOST RESTRICTIVE FOR THE OPERATION INTENDED.

Table V–2 (Cont'd.)

SPECIFICATION SECTION	DESCRIPTION OF ITEM
70–7 STACK EMISSION (Cont'd.) B. SMOKE INDICATOR	(a) EACH BOILER SHALL BE EQUIPPED WITH A COMBINATION VISUAL-PHOTO-ELECTRIC SMOKE INDICATOR WHICH SHALL CLEARLY INDICATE THE ABSENCE OR PRESENCE OF SMOKE. THE INDICATOR SHALL BE PROVIDED WITH AN ALARM WHICH ACTUATES WHEN THE SMOKE INTENSITY EXCEEDS THE VALUE ESTABLISHED BY THE ARTICLE ABOVE. THE INDICATOR SHALL BE PROVIDED WITH AN AUTO-SEMI-AUTO PRESSURIZED LENS CLEANING SYSTEM TO INSURE CLEANLINESS OF THE LENS. THE INDICATOR SHALL BE VISIBLE IN THE VICINITY OF THE CENTRAL CONTROL CONSOLE. A RECORDER SHALL BE COORDINATED WITH THE SMOKE INTENSITY ALARM TO RECORD THE DURATION OF POLLUTION ABOVE THE STANDARDS ESTABLISHED BY ARTICLE ABOVE.
70–8 INERT GAS SYSTEMS	(a) ALL TANKERS OVER 100,000 DWT AND HAVING TANK SIZES GREATER THAN 10,000 CUBIC METERS SHALL BE EQUIPPED WITH AN APPROVED INERT GAS SYSTEM TO PREVENT TANKER CASUALTIES FROM FIRE AND EXPLOSION.
94–4 RADAR/COLLISION AVOIDANCE SYSTEM	(a) A RADAR SYSTEM INCLUDING A COLLISION AVOIDANCE DISPLAY AND ALARM SYSTEM SHALL BE INSTALLED.

One of the latest additions to the MarAd specifications and a suggested procedure for Title XI tank vessels is a cargo/ballast system that employs the "Load-On-Top" (LOT) method for reducing vessel operational oil dishcarges to coastal waters.

The LOT method is devised to limit the discharge of oil from tankers caused by pumping oily ballast water and oily tank washings overboard. In the LOT system, ballast water carried in cargo tanks is first allowed to settle to the bottom and then most of it is pumped overboard. The remainder of the oily ballast and washwater is transferred to a slop tank which provides futher settling of the water from the oil before the separated water is discharged. Fresh cargo oil is loaded on top of the residual oil remaining in the slop tank; hence the term "load-on-top." The steps of the LOT cleaning and ballasting method are illustrated in Figure V-1.

Presently new methods and designs are being implemented and research carried out to improve the LOT method. A significant part of this operation, particularly for crude oil tankers, is the thorough cleaning or washing down of the cargo tanks which must take place on every ballast voyage. The traditional method of tank washing consists of revolving nozzles connected to the end of a hose lowered to various levels in the tank to be washed. The nozzles revolve around both a vertical and horizontal axis by the action of the wash water at a pressure of about 160 psi and a temperature of about 170°F to 180°F. This system is known as the Butterworth System.

A new method being employed to improve LOT is a combination of several slop tanks as a Cascade System which allows further settling and reduction of the oily content of the wastewater that may be discharged overboard.

Also, improvement in the design of the slop tank is being considered. The shape and configuration of the slop tank, the positioning of the inlets, outlets, baffles or weirs in the tank and the use of heating coils and chemical flocculants will help avoid excessive turbulence and

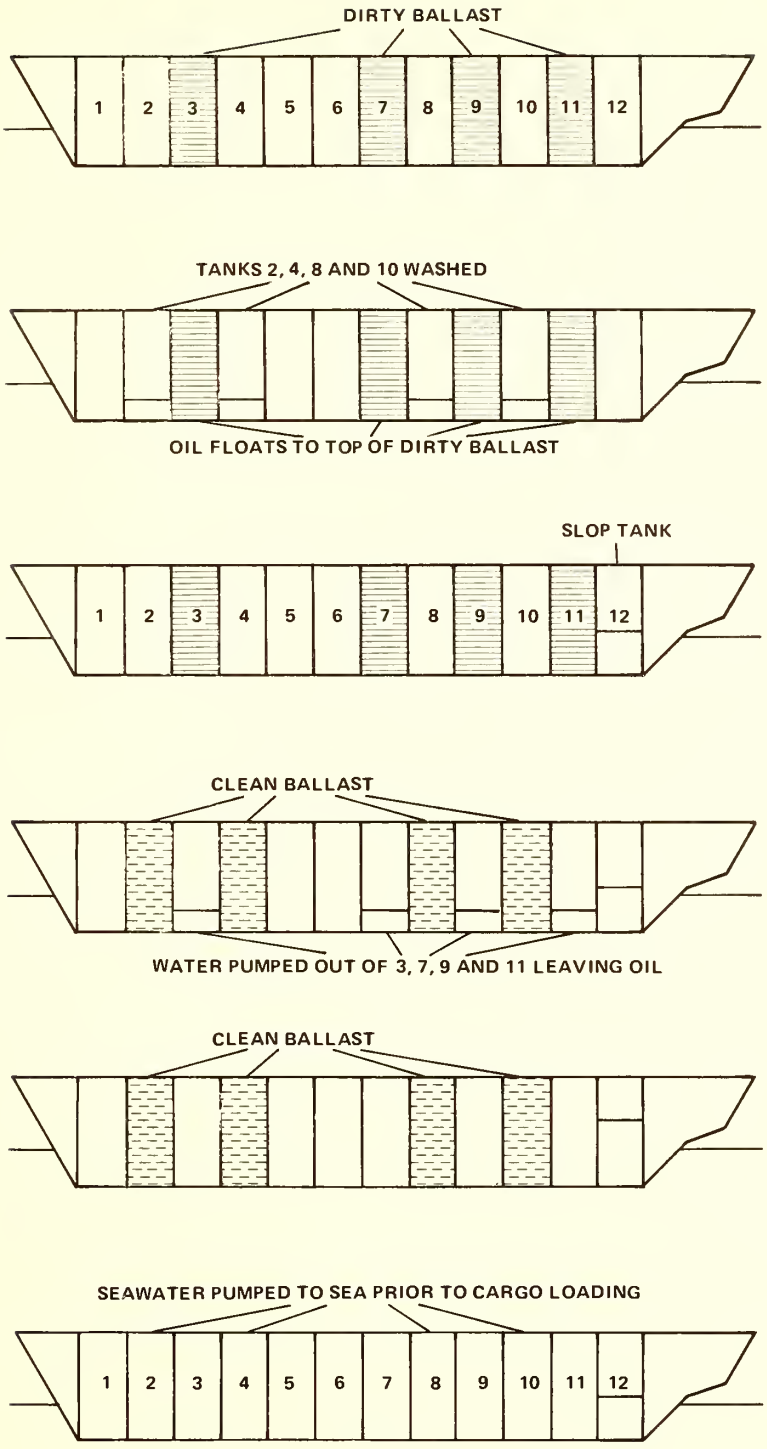

Figure V–1 SIMPLIFIED ILLUSTRATION OF LOT PROCEDURE

SOURCE: Tanker Pollution Abatement Report, U.S. Dept. of Commerce/MARAD, July 1977

entrainment of oil with the water, thereby reducing the oil content of the decanted water discharged to the sea.

All tankers will be fitted with an oil content monitoring arrangement to check the purity of any water discharged directly to the sea from the slop tanks. Also effective oil/water interface detectors are being considered for rapid and accurate determination of the oil/water interface.

If all tank vessels employed a 100 percent efficient LOT system 100 percent of the time, tank cleaning and ballasting operations would not be a significant source of oil pollution (4).

Exxon International Company, Tanker Department, under contract to the Maritime Administration developed a "crude oil washing process" for washing the tanker's cargo tanks with the crude oil cargo as the washing fluid. Crude oil washing has proven to be more effective than water washing because crude acts as a solvent, dissolving sludge and sediments. IMCO has adopted crude oil washing as an alternative to segregated ballast for existing tankers.

The majority of tank vessels engaged in the domestic trade are product carriers, except possibly those in the Alaskan trade, and therefore will not be able to utilize the LOT procedure. Unlike tankers in the crude oil trade which will clean on an average of 30-40% of their tanks on each ballast voyage, product tankers clean a greater percentage or all of their cargo tanks during the ballast voyage. This is because of the uncertainty of the next cargo and the concern for contamination of the subsequent cargo by the residues of the previous one. The residues from a product tanker are discharged to a slop tank and retained on board for discharge to a reception facility.

Another recent addition to the MarAd specifications is the collision avoidance radar system for vessels which is considered to be one of the most advanced systems in preventing pollution accidents. This system is capable of tracking fixed and moving targets, providing information with respect to such objects and sounding a warning signal if a collision is

possible. Such a system provides an automatic radar watch, together with course and speed information necessary to avoid collisions which could result in serious polluting incidents.

Collision Avoidance Systems (CAS) are shipboard computers which automatically process radar data and display ship encounter situations that would lead to groundings, collisions and polluting spills. The Collision Avoidance Systems reduce the Conning Officer's workload and allows more time for decision making particularly in situations where the danger of an accident is imminent. MarAd currently requires this system on all subsidized ships and the Coast Guard has proposed regulations which would require this system installed on all vessels exceeding 10,000 gross tons.

MarAd has conducted experimental research at the Computer Aided Operations Research Facility (CAORF), National Maritime Research Center, Kings Point, New York to study deck officer performance with collision avoidance systems (5). The results indicate that a watch officer increases the miss distance to another ship, takes corrective action earlier; makes a substantial course change rather than several small changes; and achieves greater cross-track deviations from other ships. The study revealed that the use of a CAS resulted in a 33 percent increase in miss distance as compared to the use of radar and visual sighting only.

The CAORF experiments indicated that CAS improved the miss distances to vessels in heavier traffic and in limited visibility, while miss distances with radar alone decreased in heavy traffic and did not improve in limited visibility.

Although not set forth in the anti-pollution MarAd specification, extensive research and development efforts have been sponsored to improve vessel design, maneuverability, and equipment which may mitigate the potential of tanker pollution. A brief description of each feature is listed in Table V-3.

The listed technical improvements of vessel design, maneuverability and equipment can be utilized to reduce the probability of accidental

Table V–3
POLLUTION MITIGATION FACTORS ON VESSEL DESIGN

VESSEL DESIGN FEATURES	DESCRIPTION	MITIGATION
SEGREGATED BALLAST	– SEPARATE TANKS FOR BALLAST WATER ONLY – ELIMINATES THE NEED TO CARRY BALLAST IN CARGO TANKS	REDUCES CARGO DISCHARGE TO MARINE ENVIRONMENT
DOUBLE BOTTOM	– TWO SEPARATE BUT CONTINUOUS AND WATERTIGHT PLATE STRUCTURES ALONG LENGTH AND WIDTH OF VESSEL'S BOTTOM	PROTECTION AGAINST CARGO SPILLAGE BY PROVIDING IMPACT RESISTANCE AND BUFFER FOR CARGO TANK DUE TO VESSEL GROUNDING REDUCES CLINGAGE, THEREBY REDUCES POLLUTION DUE TO BALLAST DISCHARGE
DOUBLE SIDES	– ADDED SIDE SHELL PLATING TO VESSEL	PROTECTION AGAINST CARGO SPILLAGE BY PROVIDING IMPACT RESISTANCE AND BUFFER FOR CARGO TANK DUE TO VESSEL COLLISION OR RAMMING
DOUBLE HULL	– VESSEL CONSTRUCTED WITH BOTH A DOUBLE BOTTOM AND DOUBLE SIDES	PROTECTION AGAINST CARGO SPILLAGE BY PROVIDING IMPACT RESISTANCE AND BUFFER FOR CARGO TANK DUE TO VESSEL COLLISION, RAMMING AND GROUNDING REDUCES CLINGAGE, THEREBY REDUCES POLLUTION DUE TO BALLAST DISCHARGE
REDUCED TANK SIZE	– CARGO TANK SIZE LIMITATION	MINIMIZE CARGO OIL OUTFLOW FROM CARGO TANK BREECH
INTERMEDIATE DECK (1)	– WATERTIGHT DECK LOCATED AT THE VESSEL WATERLINE WITHIN A CARGO OIL TANK. HENCE, THE PRESSURE HEAD ON THE CARGO IN THE LOWER TANKS WOULD BE REDUCED OR CAN BE MADE SLIGHTLY NEGATIVE.	IN THE EVENT OF GROUNDING, OUTFLOW WOULD BE PREVENTED AND THERE WOULD BE LITTLE CHANGE IN BUOYANCY BECAUSE THE LEVELS OF THE WATER AND OIL IN THE TANK WOULD BE SIMILAR
DEFENSIVE LOCATION OF SEGREGATED BALLAST	– USCG REGULATIONS REQUIRE 45% OF THE CARGO PORTION OF THE HULL BE PROTECTED BY BALLAST TANKS FOR NEW TANKERS 70,000 DWT OR GREATER	PROTECTION AGAINST CARGO SPILLAGE BY PROVIDING IMPACT RESISTANCE FOR CARGO TANK
INERT GAS SYSTEM	– MAINTAIN CONTROL OF ATMOSPHERE IN CARGO OIL TANKS	REMOVE FLAMMABLE VAPOR AND REDUCES PROBABILITY OF EXPLOSIONS. REDUCES CARGO DISCHARGE TO MARINE ENVIRONMENT
CRUDE OIL WASHING	– PORTION OF CRUDE OIL CARGO BEING DISCHARGED ASHORE IS DIVERTED THROUGH FIXED TANK CLEANING SYSTEM INTO THE TANKS BEING EMPTIED SO THAT EXPOSED TANK SURFACE COATED WITH THE RESIDUAL OIL ARE WASHED BY JETS OF CRUDE OIL	MINIMUM AMOUNT OF WATER WASHING IS REQUIRED FOR THE TANK TO BE USED FOR CLEAN BALLAST OR TO BE GAS–FREED FOR SAFE ENTRY BY REPAIR PERSONNEL

(1) This Vessel design feature is yet to be proven feasible.

Table V–3 (Cont'd.)

VESSEL MANEUVERABILITY FEATURES	DESCRIPTION	MITIGATION
LATERAL THRUSTERS	– INSTALLATION INVOLVES A TRANSVERSE TUNNEL THROUGH THE HULL IN WHICH A PROPELLOR IS MOUNTED THAT IS DRIVEN BY AN ELECTRIC MOTOR OR A DIESEL ENGINE	PROVIDES ADDITIONAL MANEUVERABILITY AT VESSEL SPEEDS BELOW 3 KNOTS REDUCES TUG REQUIREMENTS IN PORT AND DOCKING SITUATIONS REDUCES POTENTIAL SPILL ACCIDENTS SUCH AS COLLISIONS, RAMMINGS
CONTROLLABLE–PITCH PROPELLERS	– PROPELLERS IN WHICH THE BLADES ARE SEPARATELY MOUNTED ON THE HUB, EACH ON AN AXIS, AND IN WHICH THE PITCH OF THE BLADES CAN BE CHANGED, AND EVEN REVERSED, WHILE THE PROPELLER IS TURNING	PROPELLER PITCH MAY BE CHANGED VERY QUICKLY AND REVERSE THRUST OBTAINED FOR STOPPING PURPOSES REDUCES POTENTIAL SPILL ACCIDENTS SUCH AS COLLISIONS, RAMMINGS
IMPROVED RUDDER AREA/ RUDDER RATE	– INVOLVES INCREASING THE SIZE OF THE RUDDER AND/OR INCREASING THE RATE AT WHICH THE RUDDER CAN BE TURNED – LARGE TANKERS BENEFIT IN MANEUVERABILITY FROM INSTALLING LARGE RUDDERS – SMALL TANKERS BENEFIT IN MANEUVERABILITY FROM AN INCREASE IN RUDDER RATE	IMPROVEMENTS IN THE SHIPS ABILITY TO TURN AND CHECK A TURN CAN BE REALIZED REDUCES POTENTIAL SPILL ACCIDENTS SUCH AS COLLISION AND RAMMING
REDUNDANT PROPULSION SYSTEMS	– TWIN PROPULSION SYSTEMS INCLUDING SHAFTING, PROPELLERS AND RUDDERS	TWIN SCREW PROPULSION COUPLED WITH A TWIN RUDDER ARRANGEMENT RESULTS IN IMPROVED MANEUVERABILITY REDUCES POTENTIAL SPILL ACCIDENTS SUCH AS COLLISIONS AND RAMMINGS
INCREASED ASTERN POWER	– ASTERN THRUST INCREASES ROUGHLY AS THE 2/3 POWER OF THE SHAFT HORSEPOWER ASTERN – FOR A LARGE TANKER (191,000 DWT), INCREASING THE AMOUNT OF ASTERN SHAFT HORSEPOWER BY 100% RESULTS IN ABOUT 20–25% REDUCTION IN STOPPING DISTANCE (i.e., INSTEAD OF STOPPING IN 20 SHIP LENGTHS, CAN STOP IN 15–16 SHIP LENGTHS)	INCREASING THE AMOUNT OF HORSEPOWER AVAILABLE IN THE ASTERN DIRECTION DECREASES THE SHIP'S STRAIGHT LINE STOPPING DISTANCE AND STOPPING TIME REDUCES POTENTIAL SPILL ACCIDENTS SUCH AS COLLISIONS AND RAMMINGS

Table V–3 (Cont'd.)

VESSEL MANEUVERABILITY FEATURES	DESCRIPTION	MITIGATION
AUXILIARY BRAKING DEVICES o BRAKE FLAPS o PARACHUTES o PASSIVE DUCT SYSTEM	– REDUCES SHIP'S STOPPING DISTANCE BY ARTIFICIALLY INCREASING HULL RESISTANCE o BRAKE FLAP SURFACES ARE EXTENDED FROM THE SHIP'S HULL BY HYDRAULIC CONTROL (PLACED EITHER AT BOW OR STERN) o BASICALLY AIRCRAFT BRAKING PARACHUTES WHICH ARE PLACED IN THE WATER OVER EACH SIDE OF THE SHIP o DUCTS ARE LOCATED IN THE BOW OF THE SHIP AND CAUSE A NET DRAG INCREASE ON VESSEL BY DIVERTING THE MOMENTUM OF WATER PASSING THROUGH SYSTEM	DECREASES THE SHIP'S STRAIGHT LINE STOPPING DISTANCE AND STOPPING TIME REDUCES POTENTIAL SPILL ACCIDENTS SUCH AS COLLISIONS AND RAMMING
TUG ASSISTANCE	– USED TO ASSIST VESSELS IN HARBOR ENTRY AND DOCKING SITUATIONS BY REDUCING STOPPING TIME AND HEADREACH AND AIDING IN MOBILITY OF SLUGGISH LARGE VESSELS	TUG ASSISTANCE IN THE MANEUVERING OF LARGE VESSELS IS AN EFFECTIVE MEANS OF PREVENTING MISHAPS IN RESTRICTED WATERWAYS
STEERING GEAR RELIABILITY	– BUILT IN REDUNDANCY AND PROPER MAINTENANCE	HIGH RELIABILITY WILL REDUCE THE NUMBER OF STEERING GEAR FAILURES AND SUBSEQUENT POTENTIAL SPILL PRODUCING ACCIDENTS, SUCH AS COLLISIONS, RAMMINGS AND GROUNDINGS
MANEUVERING BOOKLET	– PROVIDES SHIP OFFICERS AND PARTICULARLY PILOTS WITH USEFUL INFORMATION ON THE MANEUVERING CAPABILITIES OF THE VESSEL	OFFICERS AND PILOTS WILL HAVE A BETTER UNDERSTANDING OF THE VESSEL'S MANEUVERING CAPABILITIES AND LIMITATIONS AND WILL REDUCE POTENTIAL SPILL PRODUCING ACCIDENTS SUCH AS COLLISIONS, RAMMINGS AND GROUNDINGS
TWIN SCREW PROPULSION	– FITTING OF TWO PROPELLERS WITH ASSOCIATED SHAFTING AND DRIVING UNITS FOR SHIP PROPULSION	IMPROVES MANEUVERABILITY DUE TO MOMENTUM GENERATED BY OPERATING PROPELLERS IN OPPOSITE DIRECTIONS OR AT DIFFERENT ROTATION RATES INCREASES TURNING RATES AND REDUCES POTENTIAL SPILL ACCIDENTS SUCH AS COLLISIONS AND RAMMINGS

Table V–3 (Cont'd.)

VESSEL EQUIPMENT FEATURES	DESCRIPTION	MITIGATION
COLLISION AVOIDANCE SYSTEM[1]	– COMPUTERIZED RADAR DATA PROCESSING AND PLOTTING AID TO ASSIST IN CORRECTLY INTERPRETING RADAR DATA TO AVOID COLLISIONS. – AUTOMATICALLY ACQUIRING TARGET SHIP ON RADAR, COMPUTING TARGET SHIP COURSE AND SPEED AND DETERMINING CPA ALARMS SOUND IF TARGET SHIP PASSES TOO CLOSE TO OWN SHIP.	AVOIDS SPILL POLLUTION INCIDENTS BY REDUCING THE CONNING OFFICERS WORKLOAD, ALLOWING MORE TIME FOR DECISION MAKING, PARTICULARLY IN SITUATIONS WHERE DANGER OF SHIP COLLISION IS IMMINENT.
RADAR [2]	– A RADIO DETECTION AND RANGING DEVICE THAT PROVIDES AN INDICATION RELATIVE TO OWN SHIP OF THE POSITION OF OTHER SURFACE VESSELS, OBSTRUCTIONS, BUOYS, SHORELINES AND NAVIGATIONAL MARKS. – DESIGNED TO SEE THROUGH POOR VISIBILITY CONDITIONS (DARKNESS, FOG, SNOW, HAZE, ETC.)	AIDS IN AVOIDING COLLISIONS AND PROVIDES NAVIGATIONAL ASSISTANCE.
DOPPLER SPEED DEVICE	– A SONAR SPEED DEVICE THAT TRANSMITS SOUND WAVES DOWNWARD FROM THE HULL OF A SHIP INTO THE WATER WHERE SOUND WAVES ARE REFLECTED BACK TO THE HULL BY BOTTOM OR WATER MASS. – SPEED ACCURACY 0.1 KNOT OR 1% OF SPEED, WHICHEVER IS GREATER.	IMPROVES ACCURACY OF COLLISION AVOIDANCE COMPUTATIONS, IMPROVES DOCKING BY PROVIDING ACCURATE LOW SPEED DATA.
LORAN C NAVIGATION SYSTEMS [3]	– A PULSED RADIO, HYPERBOLIC NAVIGATIONAL SYSTEM THAT PROVIDES A SHIP'S POSITION FROM MEASUREMENTS OF THE DIFFERENCES IN TIMES OF ARRIVAL OF RADIO SIGNALS TRANSMITTED FROM PAIRS OF SHORE STATIONS AT KNOWN LOCATIONS. – LORAN C VESSEL POSITIONING IS ACCURATE TO WITHIN ¼ NAUTICAL MILE.	ALLOWS A VESSEL TO NAVIGATE SAFELY ALONG INTENDED TRACK AIDS IN AVOIDING GROUNDING AND COLLISIONS

NOTE: 1. MARAD SPECIFICATIONS REQUIRE CAS FOR ALL SUBSIDIZED TANKERS

2. PROPOSED COAST GUARD REGULATIONS REQUIRE RADAR EQUIPMENT ON ALL VESSELS OVER 10,000 GROSS TONS

3. PROPOSED COAST GUARD REGULATIONS REQUIRE LORAN C EQUIPMENT ON ALL VESSELS OF 1,600 GROSS TONS OR MORE.

SOURCE: U.S. Department of Commerce/Maritime Administration, A Study of Tanker Construction Design, Equipment, and Operating Features Related to Improved Pollution Abatement, July 1977.

spills. The design improvements apply to tank vessels whereas the maneuverability devices and equipment may be installed either on the tank vessel or on other vessels which could collide with tank vessels and cause a major spill.

5. INTERNATIONAL STANDARDS

By international agreement through the United Nations a special agency entitled Intergovernmental Maritime Consultative Organization (IMCO) was established to provide maritime regulations and issue vessel construction requirements for the waterborne commerce of bulk liquid commodities. The findings of this organization are voluntarily accepted by the United States to guide in vessel regulations and construction. The U.S. Congress in adopting the Ports and Waterways Safety Act of 1972 intended to complement and implement IMCO findings through Coast Guard construction design standards and regulations. Under Title D of this act the U.S. Coast Guard is authorized to develop new standards for vessels carrying polluting substances (6).

The construction and design specifications administered by federal agencies are equal to or more stringent than the general ship specification standards developed by the United Nations Intergovernmental, Maritime Consultative Organization (IMCO) which oversees international merchant fleet vessel design for purposes of safety and pollution prevention.

6. NATIONAL STATUTES AND REGULATIONS

a. U.S. COAST GUARD REGULATORY AUTHORITY

The laws which give the Coast Guard the authority to develop regulations relating to specific dangerous chemical cargoes are contained in:

- The Dangerous Cargo Act (P.L. 78-809)
- The Tanker Act (P.L. 74-765)
- The Espionage Act (P.L. 83-777)
- The Ports and Waterways Safety Act (P.L. 92-340)

The Dangerous Cargo Act of 1940 authorizes the Coast Guard to regulate all waterborne bulk dangerous cargoes other than bulk flammable or combustible liquids. Examples of bulk cargoes regulated under this act are ammonia, chlorine, sulfuric acid, hydrochloric acid and molten phosphorus.

The Tanker Act of 1936 assigns responsbility to the Coast Guard for regulating the bulk water transportation of flammable and combustible liquids. As the name indicates, the Act applies particularly to tank vessels. Unlike the Dangerous Cargo Act, bulk cargoes are primarily petroleum products and are classified in the regulations on the basis of flash point and Reid vapor pressure.

The Espionage Act of 1954 and Executive Order 10173, as amended, assign responsbilities for port security to the U.S. Coast Guard. Although the name implies concern only with subversive activities of an enemy, the scope of responsibility includes regulations of designated waterfront facilities which may jeopardize normal functioning of a U.S. port. In accordance with this Act, the Coast Guard administers regulations covering: (1) the handling of dangerous cargoes on waterfront facilities and onboard vessels and (2) vessel movements, as necessary, to assure the safety of ports, vessels and waterfront facilities.

The Ports and Waterways Safety Act of 1972 provides the most important legislation empowering the Coast Guard to implement regulations and promote the safety of ports, harbors, waterfront areas and navigable waters of the United States. This Act has two parts: Title 1 provides the Coast Guard with broad authority for controlling vessels in the nation's ports, coastal waters and waterways, for operating vessel traffic control systems, and for improving the safety of the marine transportation system, as a way of preventing pollution; Title II directs the Coast Guard to develop new regulations and establish standards for vessels carrying polluting substances and provides for the establishment of comprehensive minimum standards of design, construction and operation of vessels to protect the environment. These standards will apply to all vessels documented under the laws of the United States or for all vessels entering the navigable waters of the U.S.

b. ENVIRONMENTAL PROTECTION AGENCY REGULATORY AUTHORITY

The regulation of the domestic waterborne commerce industry by the Environmental Protection Agency is primarily through control standards issued for solid waste, sewage, air, and cargo discharges. The primary legislative acts which authorized the EPA to promulgate the regulations of the industry are:

- Water Quality Improvement Act of 1970 and 1972 Amendments
- Marine Protection, Research and Sanctuaries Act of 1972
- Clean Air Amendments

Water Quality Improvement Act of 1970. By this Act Congress declared that it is the policy of the United States that there should be no discharges of oil into or upon the navigable waters of the United States, adjoining shorelines, or into or upon the waters of the contiguous zone.

Under this Act the EPA has the authority to set standards limiting the discharge of oil in U.S. navigable waters, adjoining shoreline and the contiguous zone.

Federal Water Pollution Control Act Amendments of 1972. The most significant national goals of these amendments relating to the marine environment are:

- the discharge of pollutants into the navigable water be eliminated by 1985,
- wherever attainable, an interim goal of water quality which provides for protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on water to be achieved by 1983.
- the discharge of toxic pollutants in toxic amounts be prohibited, and
- a major research and demonstration effort be made to develop technology necessary to eliminate the discharge of pollutants into the navigable waters, waters of the contiguous zone, and the oceans.

While the 1972 Amendments are directed primarily at water pollution from land-based municipal and industrial sources, they do contain some provisions which relate to vessels. In particular, the Amendments extend the present provisions concerning liability for clean-up costs which apply to oil under the Water Quality Improvement Act Amendments to hazardous substances and create a new penalty for the discharge of hazardous substances which cannot be cleaned up. This Act required EPA to promulgate standards of performance for marine sanitation devices to prevent the discharge of untreated or inadequately treated sewage into or upon the navigable waters of the United States from vessels. The long range standard is for no discharge of sewage from vessels into U.S. waters.

Marine Protection, Research and Sanctuaries Act of 1972. This Act requires a permit from the Environmental Protection Agency for all dumping in U.S. waters and the contiguous zone and dumping of material transported from the United States anywhere in the oceans.

The ocean dumping law prohibits disposal of radiological, chemical, and biological warfare agents and any high-level radioactive wastes in the ocean, and it provides for regulation of all other dumping through issuance of permits by EPA. U.S. jurisdiction applies anywhere on the high seas to dumping by Government vessels and to dumping of materials that have been transported from U.S. ports. All vessels in U.S. territorial waters and the contiguous zone are also subject to U.S. controls. The law calls for a comprehensive research and monitoring program on the effects of ocean dumping and authorizes the establishment of marine sactuaries for recreation, conservation and ecological purposes.

Clean Air Amendments of 1970. The Clean Air Amendments of 1970 set in motion a nationwide federal and state program to achieve acceptable air quality. In essence, the Clean Air Act requires achievement of national standards of ambient air quality to protect public health by 1975. These standards are known as primary standards. Secondary standards will be designed to protect aesthetics, property and vegetation.

The Act requires that EPA implement regulations which will cover the emissions of shore facility stack gases for various industry plants including those relating to steam generating plants. While these regulations would apply to shipyard facilities, they would not apply to ships because they are not fixed installations. The spirit of this act is carried by the state statutes which, in some major port areas, do exercise control of vessel stack and incinerator emissions.

c. U.S. ARMY CORPS OF ENGINEER'S REGULATORY AUTHORITY

The U.S. Army Corps of Engineers has had a long involvement with developing and regulating domestic shipping principally within ports and on the inland waterway system. Under the current federal regulations (33 CFR Part 209). The Corps has regulatory authority over the discharge of refuse into navigable waterways, and is charged with the responsibility to ensure the preservation of the quality of the aquatic environment. In response to the federal pollution abatement policies the Corps of Engineers personnel can be enlisted under 33 CFR 151 to enforce Coast Guard regulations including swearing out warrants and making arrests.

d. STATE STATUTES

The control of pollutant waste streams from inland shipping is also controlled by state statutes. All states have enacted water quality measures to protect their waterways from sources of pollution. These regulations are applicable to controls of shipborne waste systems and discharges as a result of negligent cargo handling. Certain states which have high air pollution levels have enacted standards for vessel stack emissions. These requirements are primarily enforced to reduce sulphur dioxide emissions in the non-attainment areas. The vessels engaged in these areas would be controlled accordingly.

The individual states have always had the power to legislate pilotage requirements within their waters. With this instrument the state retains some direct control in the daily operations of the industry within its waters. The states also have the power to exercise control so long as it does not interfere with federal and international relationships.

Operations within the Great Lakes are governed by the Great Lakes Water Quality Agreement of 1972. This agreement consists of a number of annexes, several of which discuss the control of vessel design, construction, operation and the control of vessel wastes. Operation of vessels under this title would come under the pollution abatement articles of this agreement.

B. MARINE TRANSPORTATION SERVICES

The creation of a safer navigation environment through federal assistance and control to the shipping industry is a major mitigative action to prevent groundings and collisions, and their resultant oil and chemical spills. The U.S. Coast Guard, the Department of Commerce, and the U.S. Corps of Engineers all provide on a daily basis marine and inland waterway transportation services.

1. U.S. COAST GUARD

The U.S. Coast Guard is the principal federal agency for providing the required assistance. Their assistance can be divided into categories as: navigational aid systems, communication systems, vessel traffic systems, and cargo information.

a. NAVIGATIONAL AIDS

Techniques developed and employed for the industry include: improved aids to navigation, (buoys, ranges, structures) radar systems, satellite navigation systems and the Loran navigation systems. These systems are being continuously upgraded to provide faster and more accurate vessel positioning capabilities.

b. COMMUNICATION SYSTEMS

With the enactment of the Bridge to Bridge Radiotelephone Act of 1971, all vessels operating in navigable waters of the U.S. are required to have bridge to bridge communication systems. The Coast Guard is charged with the responsibility of enforcing this act.

c. VESSEL TRAFFIC SERVICE (VTS)

One area of marine operations with clear implications for vessel safety and environmental protection is a Vessel Traffic Service (VTS). The Coast Guard defines VTS as: "an integrated system encompassing the variety of technologies, equipment and people employed to coordinate vessel movements in or approaching a port or waterway."

The Ports and Waterways Safety Act enacted by Congress on July 10, 1972, authorized the Coast Guard to: "(1) establish, operate and maintain vessel traffic services and systems for ports, harbors, and other waters subject to congested vessel traffic; (2) require vessels to carry or install electronic or other devices necessary in the traffic system; and (3) control vessel traffic, when conditions are hazardous or congested, by specifying times of vessel movements, establishing routing schemes, establishing vessel size and speed limitations, and restricting vessel operations to those vessels with particular operating capabilities."

Both historical casualty data and the future outlook for waterborne commerce indicate a need for improved marine traffic safety.

The objectives of Vessel Traffic Service is to reduce the probability of vessel collisions, rammings and groundings while facilitating the orderly movement of vessels within or through navigable waters. Vessel Traffic Service can make significant contributions to this objective.

A U.S. Coast Guard study (7) of 22 major U.S. ports and waterways concluded that some types of casualties could be avoided by the implementation of Vessel Traffic Service (VTS). Each area was evaluated on the basis of economic losses, pollution incidents, and deaths and injuries resulting from vessel casualties, and the effectiveness of various levels of VTS in reducing those losses. Those areas studied are listed in Table V-4 in descending order beginning with the ports and waterways most in need of VTS. For each location, an estimate has been made of the effectiveness of the recommended level of VTS in reducing casualties. The levels of VTS referred to in Table V-4 are as follows:

Table V–4
VTS REDUCTIONS FOR 22 U.S. PORTS OR WATERWAYS

PORT OR WATERWAY	FY 69 – 72			VTS LEVEL SELECTION	ESTIMATED % REDUCTION BY SELECTED VTS LEVELS	
	NO. OF C/R/G CASES ***	NO. OF VESSELS				
		IN C/R/G ACCIDENTS	IN TYPE 1 ACCIDENTS *		IN ALL C/R/G ACCIDENTS	IN TYPE 1 ACCIDENTS*
NEW YORK	320	611	172	$L_O{}^2L_2{}^2L_3$	29	52
NEW ORLEANS	237	564	211	$^2L_2L_3$	19	33
HOUSTON/GALVESTON	145	329	172	L_2L_3	25	30
SABINE – NECHES (ICW 265 - 290)	143	310	131	$L_O{}^2L_2$	23	24
CHESAPEAKE BAY	116	229	64	$L_OL_2L_3$	17	52
ICW 80 - 99 (MORGAN CITY)	83	248	126	L_RL_2	36	15
ICW 107 - 129 (COTE BLANCHE)	41	148	116	L_4	53	63
BATON ROUGE	55	126	71	L_2	35	49
SAN FRANCISCO	81	124	12	L_2L_5	7	17
ICW 50 - 60 (HANNA)	37	109	63	L_2	40	60
CHICAGO	58	118	16	L_R	–	–
DELAWARE RIVER & BAY	107	167	28	L_O	–**	–**
TAMPA	108	204	20	L_O	–	–
PUGET SOUND	42	83	33	L_2	5	12
MOBILE	51	101	3	L_O	–	–
DETROIT RIVER	44	65	12	L_O	–	–
ICW 155 - 179 VERMILLION RIVER	26	82	59	L_O	–	–
ST. LOUIS	29	114	8	L_O	–	–
LONG ISLAND SOUND	30	55	13	L_O	–	–
LA/LB	29	53	4	L_O	–	–
CORPUS CHRISTI	30	40	7	L_O	–	–
BOSTON	15	29	3	L_O	–	–

* Collisions in meeting, passing, and overtaking situations
** Indicates that no VTS effort was recommended
*** C/R/G: Collisions, Rammings, Groundings

SOURCE: Vessel Traffic Systems Analysis of Port Needs, U.S. Coast Guard Study Report, August 1973.

L_0 - Vessel Bridge-to-Bridge Radio Telephone.

L_R - Regulations - for example, regulations establishing a relationship between tow boat characteristics and size of tow.

L_1 - Traffic Separation Scheme (TSS).

L_2 - Vessel Movement Reporting System (VMRS). A system where vessels relay navigational information to a shore-based control center.

L_3 - Basic Surveillance - shore-based radar for observing vessel positions and movements.

L_4, L_5 - Advanced Surveillance and Automated Advanced Surveillance - Collision avoidance radar and computer interfaced components.

VTS appears most effective in reducing collision casulaties and least effective in rammings. VTS would not prevent casualties directly resulting from mechanical failures, grounding and rammings due to winds or currents, collisions caused by pleasure craft, and rammings at piers and docks (7).

The Coast Guard is now operating major advanced Vessel Traffic Services (L_3, L_4, and L_5) in Puget Sound, San Francisco and the Houston-Galveston area. The Puget Sound VTS is a mandatory system and the San Francisco and Houston-Galveston VTS systems are voluntary at this time. Vessel Traffic Services are underway for the Lower Mississippi River (New Orleans) and for the New York areas.

d. CARGO INFORMATION

When shipment of a dangerous chemical cargo is planned, the shipper or carrier may contact the U.S. Coast Guard for assistance regarding rules and regulations. For chemical cargoes not covered in the regulations, the appropriate Coast Guard office will provide the criteria of information upon which approval is based. The personnel in the Cargo and Hazardous Materials Division at Coast Guard Headquarters in Washington, D.C. review proposed shipments and provide information on approvals.

2. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION MARINE TRANSPORTATION (NOAA)

NOAA primarily aids the marine shipping industry by publishing the most up to date navigational charts, notes and tables for all navigable waterways within the U.S. This agency also provides vessels with current weather conditions and issues weather warnings as required. These two activities help to promote a safer navigational environment and thus reduces environmental risks.

3. U.S. ARMY CORPS OF ENGINEERS

The Corps of Engineers is the principal agency for developing and maintaining safe waterways from the civil engineering viewpoint. The Corps provides all the channel straightening, bend easing, and channel dredging required to maintain the navigable waterways in a safe condition. The Corps has permit power on all construction along the nation's navigable inland waterways and along the coastal shelf. By regulating the development, the Corps can ensure that safe navigation in the waterways is promoted and maintained.

C. INSPECTION AND MONITORING

Inspection and monitoring of the waterborne commerce industry operations for safety and pollution abatement by federal agencies constitutes a meaningful program for the mitigation of environmental damage. The primary responsibility for inspection and monitoring of the industry is the U.S. Coast Guard. In response to this responsibility the Coast Guard operates a multifaceted program of shore, shipboard, airborne and remote sensing surveillance systems. Inspection and monitoring of the oil transfer operation between ship and terminals is a major program in the Coast Guard harbor patrol function. Under these inspection systems both the facilities and management of the transfer action are monitored to ensure safe transfers. Included in this program is the periodic annual or biannual physical inspection of the vessel. Since July 1, 1974, U.S.

inspected vessels have been required to comply with the Pollution Prevention Regulations as a condition of certification. Without a valid certificate, the vessel may not continue in commercial service.

The Captain of the Port (COTP) or Officer in Charge, Marine Inspection (OCMI) may order oil transfer operations suspended when he finds there is a condition requiring immediate action to prevent the discharge of oil. The Coast Guard regulations require each tanker crew to maintain an Oil Record Book. Vessels engaged in domestic trade must enter any information regarding ballasting, deballasting or cleaning of the cargo tanks, disposal of oily residue from the slop tanks or from other sources or any accidental or exceptional discharges of oil. Through the periodic inspection of the book, management problem areas and possible sources of polluton incidents can be determined.

Pollution monitoring is a continuous function within the Coast Guard. Under this program harbor, channel and oceanic surveillance is conducted to detect spills, and monitor general vessel operations. This program also permits the Coast Guard to board vessels from which sources of pollution are suspected to occur. The routine inspection of the waterways and vessel traffic are positive programs to control unsafe operations which could lead to polluting incidents.

In response to the provisions of the Federal Water Pollution Control Act of 1972 the Coast Guard expanded its pollution surveillance program to incorporate: airborne remote sensing, over wide range areas which have high levels of pollution incidents, remote local area surveillance within ports, estuaries and near shore areas; spill sampling identification, and source isolation.

The Coast Guard has developed a sensor system called Airborne Oil Surveillance System (AOSS II), which can detect illegal discharges of oil and provide documentation for enforcement action. The system employs a combination of current state-of-the-art sensors which are integrated to provide day/night surveillance capabilities, effective in all but extreme weather conditions. Although it is still considered a prototype, AOSS II has proven itself to be a capable tool for detecting and mapping

oil spills. In the fall of 1978, the Coast Guard will contract for its first production sensor system, called Airborne Remote Identification System (ARI), to be installed aboard six new medium range surveillance aircraft.

The Coast Guard has also been developing prototype oil-on-water sensors capable of continuous automatic monitoring of local, high risk spill areas in harbors, rivers and deepwater sites. These sensors are of two types: buoy mounted, or fixed (to stationary objects). Telemetry generated data is transmitted to receiver units in local Captain of the Port (COTP) or Marine Safety Offices using current telephone circuitry.

A scientific technique has been developed by the Coast Guard to identify the source of an oil spill in a waterway. This system utilizes fluoresence spectroscopy, infrared spectroscopy, thin-layer chromatography, and gas chromatography, and is capable of providing a correct match or mismatch in 99.99% of all comparisons. A number of mini labs located at COTP units aid in identifying oil spills by utilizing fluorescence spectroscopy and thin-layer chromatography.

The overall inspection and monitoring program demonstrates the emphasis the federal government is placing on eliminating spills and prosecuting the responsible parties.

D. PERSONNEL QUALIFICATION STANDARDS AND TRAINING

An alternative approach to reducing marine pollution from waterborne commerce is to improve the training of tanker, barge and terminal personnel and to improve testing and certification procedures to insure that such personnel have the necessary skills. The importance of adequately trained personnel in marine transportation systems is graphically demonstrated in accident statistics. U.S. Coast Guard studies have indicated that 85 percent of the casualties were related to personnel errors.

Personnel error has constantly been a major contributor to the level of pollution in the environment. Higher personnel standards augment the pollution abatement effect of improved hardware since higher levels of

technology will require improvement in the knowledge and capabilities of operating personnel both in the vessel's crew and at the terminal. While the degree of environmental impact mitigation attributed to training cannot be quantified, it would follow that the more intensive and formalized training programs become and the more rigorous the examination and certification procedures, there should be a major reduction in pollution incidents and related cleanup as a direct result of advanced training. The U.S. laws and regulations affecting U.S. flag ships are both more stringent and far more enforceable in matters of safety of personnel, property and environment than international conventions or treaties.

Both industry and the federal government have cooperated in training programs to upgrade personnel competence. The Coast Guard, MarAd and Environmental Protection Agency all have current educational and training programs related to marine pollution abatement. Formal training programs for merchant marine personnel are offered in a variety of facilities both public and private. The major installations are the U.S. Merchant Marine Academy, operated by MarAd, six State Maritime Academies and Colleges, the three Regional Training Centers operated by MarAd and the several industry training centers operated under joint trusteeship of particular maritime unions and steamship company groups. All of these installations are in close contact with the U.S. Coast Guard and MarAd with particular concern for updating curriculum content in keeping with new skill and knowledge needs, whether enforced by regulation or not.

The U.S. Merchant Marine Academy, operated as a fully accredited college by MarAd for the education and training of new Engineering and Deck Officers, offers an environmental pollution control course consisting of two ten-week sessions.

The Maritime Institute of Graduate Studies located at Lithicum, Maryland offers a refresher training course to Merchant Marine Officers including simulated radar exercises and cargo handling and engine room control from a centralized control panel.

Shiphandling simulators are located at the U.S. Merchant Marine Academy, Kings Point, New York (sponsored by MarAd) and at Marine Safety

International, Inc., LaGuardia Airport, New York, New York (an industry school). The shiphandling simulators are a mock-up of a life-size ship's bridge surrounded by a projection screen. Projected on the screen are images of a ship entering specific ports or harbors enroute to a particular terminal site. The operating characteristics of the vessel are reproduced in the simulator. Control changes made by the ship's officers on the mock-up bridge will produce changes in the projected image on the screen. The simulator is programmed to vary weather conditions, time of day, depth of water, pecularities of channels and traffic patterns.

MarAd's National Maritime Research Center at the U.S. Merchant Marine Academy has cooperated with the U.S. Coast Guard in a major revision of the Tankerman Manual, a U.S. Coast Guard publication specifically designed to cover the field of knowledge for the special skills required on board tank vessels. The basic requirements for these skills are specified in: Rules and Regulations for Licensing and Certification of Merchant Marine Personnel.

The Tankerman Manual covers new technologies, new operational procedures and pollution control, in keeping with the intent of the laws and regulations. The Manual constitutes a basic reference work in the field, has direct use as a course text in formal training programs for seafarers endeavoring to acquire a "Tankerman" rating, and is the source for development of examination questions for issue of the rating document.

With specific reference to environmental protection courses designed for seafarers and terminal personnel, regardless of ship type, MarAd issued on October 21, 1975 its Cirriculum on Marine Pollution Abatement and has prepared a pollution abatement manual which is available to all existing maritime training facilities.

In MarAd's Regional Offices, ongoing short courses are offered to active merchant mariners in collision avoidance radar, Long Range Radio Navigation (LORAN), firefighting and damage control. Since July 1, 1971, the U.S. Coast Guard has required that all licensed deck officers satisfactorily demonstrate their capabilities as qualified Radar Observers

every five years in order to continue sailing on their licenses. New Coast Guard regulations pertaining to licensing of merchant marine officers and seamen, include questions in the area of environmental pollution, laws, regulations and procedures to prevent pollution. The U.S. Coast Guard examinations achieve some measure of assurance that merchant mariners possess the basic knowledge necessary to minimize or avert environmental damage. Failure to satisfactorily answer these pollution abatement questions can lead to non-issue or non-renewal of the mariner's document. Pollution incidents found to be caused by personnel fault can lead to action by the U.S. Coast Guard in suspension or revocation of license documents.

In addition to seaman training, extensive nationwide training programs have been initiated in oil and chemical spill control and cleanup. These training sessions are generally coordinated with federal, state and industry personnel to familiarize cleanup crews with the techniques to be employed in spill prevention, control and cleanup. These programs in relation to organized plans as defined in the facilities oil spill control and cleanup plans provide immediate mitigative control to reduce environmental degradation from oil or chemical releases.

E. SPILL CONTROL AND CLEANUP

The single most important mitigative measure for the control and cleanup of polluting spills is the formulation and enactment of spill prevention containment and countermeasure plans. These plans are developed in response to the Federal Water Pollution Control Act Amendments of 1970 and 1972 that recognized spills were inevitable and a national response plan was essential for environmental protection. All of the agencies responsible for terminal activities, ports, inland, coastal and Great Lakes waterways have established such plans. To enact the policies of the 1970 Act, the federal government established national and regional response teams to direct and coordinate pollution control efforts. The Coast Guard has the federal responsibility to control spills from the waterborne shipping industry on the high seas, coastal and contiguous zone waters and for the Great Lakes, coastal waters, ports and harbors. For spills within these defined areas the Coast Guard provides an On-Scene Coordinator who

supervises the implementation of the specific spill prevention, containment and countermeasures plan. The Coast Guard has developed quick response teams which can be rapidly deployed by air to the spill scene.

In response to the specialized spill control and restoration equipment, the Environmental Protection Agency and the Coast Guard have developed a wide spectrum of equipment for oil water separation, tanker pump out and containment equipment, oil barriers, oil absorbent, dispersant, beach cleanup equipment, and other oil control measures.

Within certain larger port and terminal areas oil spill cleanup associations have been formed by the waterway users. These organizations have assembled more equipment than an individual waterborne user could employ, and also have the necessary manpower to quickly respond to major spills and incidents.

An action plan for federal, state, and local authorities for oil spill control and cleanup was developed by the Council on Environmental Quality (the "National Oil and Hazardous Materials Pollution Contingency Plan") in August 1971 and amended in 1975. Mechanisms were established for coordinating the response to a spill of oil (or other hazardous material) among interested government agencies. The following three classes of spill volumes were established for offshore waters:

- Minor - less than 1,000 gallons
- Moderate - 1,000 to 100,000 gallons
- Major - more than 100,000 gallons

In the plan, the U.S. Coast Guard was given responsibility for developing regional plans and required to furnish the On-Scene Coordinator who is the sole responsible agent to coordinate and direct the spill control activities. The Coast Guard assigns pre-designated On-Scene Coordinators (OSCs) for each coastal region. Each OSC is responsible for the development of detailed local contingency plans to identify potential problem areas, and the available federal, state, local and commercial pollution control resources. The OSC establishes a means

for rapid and effective responses so as to avoid or minimize damage to the environment from pollution incidents which occur within his region. Local contingency plans are further supported through regional contingency plans which contain the means for rapidly accessing expertise and equipment from other governmental agencies when needed.

The On-Scene Coordinator for an area is notified whenever a discharge occurs in his region. He evaluates the situation and initiates further federal response efforts as appropriate. It is the policy of the federal government to encourage the party responsible for the discharge to undertake appropriate removal actions. These actions are continually monitored by the OSC. If the responsible party fails at anytime to undertake proper removal actions, or the identity of the responsible party is unknown, the OSC will act to take the steps necessary to remove the pollutant. When federal actions become necessary commercial cleanup contractors are utilized whenver possible. Coast Guard Strike Team personnel advise in cleanup efforts when contractors are unavailable or do not possess the necessary equipment or expertise. State pollution response capabilities exist in some regions of the country and these resources may also be utilized by OSCs during federal cleanup operations. Personnel having specific expertise in the various areas that are involved in the overall decision making process, such as bird cleaning, sensitivity of an estuary, etc., are made available to the OSC for his use in an advisory capacity. Such advisors originate from the National Strike Force, Regional Response Teams consisting of federal, state, and local agency representatives.

The Environmental Protection Agency is tasked with providing OSCs to respond to pollution incidents which occur on the inland waters of the United States. Likewise, EPA has the responsibility for issuing regulations to prevent pollution from non-transportation related facilities. Thus, the two agencies work quite close to each other and have complementing programs in the areas of prevention and response which, when combined, cover all of the navigable waters of the United States.

1. OIL SPILL CONTROL AND CLEANUP

Control and Cleanup procedures following a tank vessel oil spill are an essential part of mitigating the effects of environmental damage. Any realistic environmental impact statement of tank vessel operations must also include an assessment of the effectiveness of control and cleanup measures which are now available or will be operational in the near future.

The Coast Guard has conducted a number of research and development projects to improve the state-of-the-art in containment, recovery and cleanup of oil spills.

Advanced equipment developed by the Coast Guard thus far for use in coping with pollution incidents resulting from vessel accidents includes an air deliverable, high capacity pumping system for pumping oil or oil-water mixtures from damaged tankers, a rough water oil containment system and a rough water recovery skimming system. These containment and recovery systems will function effectively in 5 foot seas, 20 knot winds, and 1-1/2 knot currents. There are several containment barriers, pumping systems, and oil recovery systems in the Coast Guard Strike Team inventory. Any or all of this equipment can be fully deployed within 24 hours of notification. Although this first generation rough seas equipment represents a significant capability and the best that exists in the world today, when on-scene conditions exceed their design limits as occurred in the ARGO MERCHANT incident, where the winds were at times in excess of 50 knots and the seas approached 20 feet, this equipment is virtually useless. Research is continuing to increase this capability, but it is recognized there are practical limits for containment and recovery of oil.

The Coast Guard has also developed a high speed surface delivery system. This device will be utilized for transporting equipment from a staging site to the scene of an incident. The system is a planed hull sled designed to be towed by helicopter or ship. Other areas which the Coast Guard is presently investigating include the identification of special requirements for response for operations in cold weather (arctic)

environments and a fast current oil recovery device that will be able to remove oil from areas with currents as strong as 10 knots.

The following describes the state-of-the-art technology developed by private industry for control and cleanup of oil spills on water.

a. OIL RETENTION BARRIERS

There are many devices (booms) for floating oil containment. Almost all booms have severe limitations regarding wave heights and currents in which they can retain 100 percent of the spilled oil. Short, choppy waves are usually most troublesome because most barriers cannot readily follow these waves. Oil can flow out underneath or slosh over the top. Strong currents also entrain oil droplets near the front of the contained slick; those droplets can pass beneath the barrier. This type of containment system, however, does allow the oil removal system to be an integral part of the overall port design, which is a definite advantage over other containment concepts. Such systems can be placed around the ship after docking and removed before sailing.

Another concept in oil retention barriers is a device called a pneumatic barrier in which a continuous upward flow of air bubbles from a submerged manifold creates an upward current. At the surface the bubbles dissipate, upward water momentum is deflected and causes surface currents which can be used to oppose the potential spreading energy of oil at a given depth. When equilibirum is established the floating oil is essentially contained by the bubble generated currents. Breaking waves and strong natural currents require large amounts of power to generate water currents at the surface capable of containing the oil. Under these conditions some oil continuously drains over the top as small droplets, or is swept through.

The primary advantage of the pneumatic system is its permanent installation below the water where ships can pass over or through it so that handling of containment booms is not necessary for each vessel movement. However, separate pickup and removal equipment must be available to move into and extract the contained oil.

b. SKIMMING DEVICES

There are other methods of controlling and collecting spilled oil. Skimming devices scrape oil off the water surface or force it along rotating elements (plates, disk, belts, etc.) from which it can be recovered. Vortex generating devices to separate oil and water have been developed. Magnetic liquids can be added to the oil, and recovery by magnetic pick-up devices is then possible. One of the most promising of all these collection devices for use in offshore terminal harbors appears to be a skimmer boat using an inclined plane. As the collection boat moves through the water, oil (and water-in-oil emulsions) is forced along the moving plane until it reaches the collection well from which it is pumped to an auxiliary collection tank.

c. TREATING AGENTS

A variety of treating agents have been used in the field. These include:

- Sorbents that absorb oil to form a floating mass for later collection and removal.
- Sinking agents (such as sand) create a compound or mixture dense enough to sink.
- Burning agents are chemicals or other materials which assist ignition or enhance combustion of spilled oil.
- Dispersants are chemicals forming oil-in-water suspension.
- Biodegradants are substances that promote oxidization of oil by bacterial action.
- Gelling agents are chemicals that form semi-solid oil agglomerates which facilitate removal.
- Herding agents are chemicals that concentrate the spilled oil in a small area.

Data are not readily available for the biological effects of most of above treating agents.

(1) Sorbents (8). Any material that absorbs oil and floats for later pickup and disposal (or oil removal and reuse) can be considered to be a sorbent. In laboratory experiments polyurethane foams showed the highest oil sorption capacity, while inorganic sorbents have the least. Detergents and other surface contaminants interfered with their effectiveness. Five basic operations are required to achieve oil removal by sorbents; these are:

- Sorbent broadcasting
- Oil-sorbent harvesting
- Oil-sorbent separation
- Oil storage or disposal
- Sorbent reuse or disposal

The main advantage of sorbents is that they are not affected by sea conditions. In fact, better results are achieved in the presence of waves to provide mixing energy. Lacking a mechanical retrieval system, manual labor must be used, which is a major disadvantage. In addition retrieved sorbents contribute to solid waste or air pollution problems. A surface active chemical ("herder") to prevent spreading can be used with polyurethane foam as a sorbent under favorable sea (4 to 6 foot wave) conditions. Preliminary tests indicate that the system is a feasible technique for controlling and recovering oil spills on the ocean over a broad spectrum of weather conditions.

(2) Sinking Agents (8,9). Dense materials such as sand can be used to form a compound or oil-solid mixture dense enough to sink to the bottom. Of concern obviously is what happens to bottom dwelling organisms when covered by the sunken oil-sand mixtures. The available data does not permit an adequate assessment of these effects. However, it can perhaps be assumed that any sessile epifauna (organisms living on the surface that do not move) in the area affected will be killed. Some infaunal (living in the sediments) organisms may be able to reestablish a connection to the sediment water interface and will not be killed by a lack of oxygen. However, they will likely suffer from the toxic effects of the oil.

In general, sand-water slurries which contain a cationic wetting agent to render the solid surface oil wettable in the presence of water, can cause sinking provided the wetting agent concentration is large enough to produce oleophilic (oil-wetted) sand surfaces. To prevent the formation of continuous carpets of the sunken oil-sand conglomerate on the bottom, a dispersant chemical can be sprayed on the floating oil film before the sand-wetting agent is applied.

The "National Contingency Plan" provides guidelines for the use of sinking agents. Generally, sinking agents should be used only in off-shore marine waters deeper than 330 feet where currents will not bring sediments on-shore, and only if all other methods are judged by the Water Quality Branch of EPA to be inadequate or not feasible.

(3) Burning Agents (8,9). Burning agents are materials or chemicals which aid burning of oil on water. It appears that there is little toxicity to marine organisms since the burning agents employed were either inert or non-toxic. No evidence is available to permit evaluations of the effects of burning on marine life beneath the spill area. Improved combustion would also reduce the smoke plumes by consuming more of the polluting exhausts. Field investigations have uncovered problems with wind and wave action which separated the slick in smaller pools which did not ignite and burn. Barrier containment to provide continuous burning is a possible solution.

(4) Dispersants (8,9,10). Dispersants are chemical agents or compounds which emulsify, disperse, or solubilize oil into the water column or act to further the surface spreading of oil slicks in order to promote dispersal of oil into the water column. Toxicity and secondary effects of dispersal agents to marine life has been the object of considerable research (9).

In a circulating aquarium system, the toxicity of two types of non-ionic, oil-dispersing agents was tested on common marine species: an edible mussel, winter flounder, soft shell clam, mummichog, Atlantic silversides, and fourth stage lobster larvae. The very short term life period (24 hours) suggested that the high toxicity was due to the

relatively volatile solvent fraction of the oil dispersant. The toxicity of both dispersants to marine plankton was also investigated at a concentration of 30 ppm (dispersant). Before adding the dispersants, all organisms were alive and vigorous. Twenty-four hours later, 90 percent were dead or moribund. Recently developed dispersants have toxicities less than oil.

Field studies of the effects of dispersants also document their toxicity to a variety of marine organisms.

Because of the above mentioned problems concerning the use of dispersants in controlling oil spills, rigorous restrictions and guidelines were established by CEP in their National Contingency Plan. Dispersants were not to be used: (1) on any distillate fuel oil; (2) on any spill of less than 200 barrels; (3) on any shoreline; (4) in waters less than 100 feet deep; (5) in any waters containing commercial populations, or breeding, or passage areas for fish or marine life which by exposure to the dispersant or dispersed oil would render them less marketable; (6) in waters where winds or currents would carry the dispersed oil to shore within 24 hours (in judgement of EPA); or (7) in waters where the surface water supply would be affected.

However, dispersants may be used in any place and at any time if, in the judgement of the Coast Guard's On-Scene Coordinator, their use will: (1) prevent or substantially reduce the hazard of fire to property; (2) in the judgement of EPA, prevent or reduce substantial hazard to vulnerable waterfowl; and (3) in the judgement of EPA, result in the least overall environmental damage.

The affected states would be consulted in all cases and the state dispersant laws, regulations, or written policies would supersede the above.

d. TYPE OF LOCATION AND CONTROL OF OIL SPILLS

Control of accidental oil spills is considered in three subgroups depending on the location of the spill: (1) in port or harbor; (2) at sea; or (3) near shore and coastal inlets.

(1) Containment and Cleanup in Port and Harbor (8). Because of the chronic and continuing nature of small spills from routine operations in harbor areas, it is anticipated that containment equipment will be in place surrounding the site of normal loading or unloading. In that way, immediate containment and removal could take place should oil be spilled.

Control of oil spills at a terminal or port can be greatly facilitated by proper terminal design. Consideration must be given to this factor in site selection and design facilities. A properly planned facility could trap spilled oil from tankers or could allow slips to be sealed off during transfer. Breakwaters protecting ports can make floating containment barriers surrounding ships function more effectively by reducing wave conditions. Strong currents could also be reduced by proper port design and such designs improved by using a hydraulic model test.

Using known containment and cleanup techniques, it appears that control of small oil spills from ships in a harbor can be effective and is a relatively minor problem if dock site selection and design incorporates environmental considerations for proper functioning of existing oil spill containment and removal devices. If the containment or oil removal devices are ineffective, oil can spread in the harbor or terminal area to enter various ecological systems with the harmful effects as previously described.

(2) Containment at Sea. A cost effectiveness analysis (8) was made of equipment, materials and techniques applicable to removal or dispersal of oil on open waters. Parameters included oil types, spill locations (3 and 12 miles from shore) and spill sizes (2,700; 270,000; and 6,750,000 gallons). Evaluation criteria included: completeness of oil removal; removal rate; hazard and pollution; use in small areas; environmental sensitivity; temperature extremes; toxicity to marine life; and system availability.

The most practical universal system for cleaning up massive spills with a favorable cost effectiveness ratio was found to be dispersing. The next most practical system was that of containment and dispersing.

For spills up to 270,000 gallons, it was concluded that there would be no significant toxic or other deleterious effect on offshore fishing. However, for the massive 6,750,000 gallon spill, large amounts of dispersants would be required and the probability of exceeding a 5 ppm limit on dispersant concentration would be great. Finally, burning agents were judged to be the third best system based on favorable costs but limited applicability to oil types and allowable environmental conditions.

Although it is recognized that containment and recovery of spilled oil at sea is highly desirable, no system is now available that can handle the possible range of oil spill sizes or cope with waves above six to eight feet and currents greater than a knot. Such conditions are commonly experienced at sea.

One attractive possibility is combining a containment device as part of a larger system. The complete system would consist of the barrier; a removal system within the barrier to remove oil as it accumulates; a separation device; and finally a storage and disposal system for the collected oil. Such a system is not yet available.

In summary:

- Presently available containment barriers (booms) are ineffective in currents greater than 1 knot and waves 6-8 feet.

- Large removal devices have yet to be systematically developed and evaluated for optimum efficient designs; and

- Dispersants, although economic and effective in heavy seas are still toxic and their use must be restricted.

Because a capability is not available today, one must conclude that a spill of 30,000 tons or larger could not be contained effectively in the open or coastal ocean waters.

(3) Containment Near Shore and Coastal Inlets (8,9): Bays, lagoons, and many estuarine areas along much of the Atlantic and Gulf Coast are naturally protected by barrier beaches. Various inlets penetrate the

barrier beaches and provide passages for spilled oil to enter estuaries or lagoons.

In the event that oil from a major spill approaches the coast, it would be desirable to seal off the inlet(s) involved. Thus, oil would be kept out of the most ecologically important areas with a minimum effort. However, should oil reach a barrier beach area far from an inlet, natural longshore sand transport processes would tend to eventually move the contaminated sand along the shore until an inlet is reached. From there, it could spread to the estuary or adjacent wetland area.

Barriers to protect inlets could be a floating mechanical or pneumatic barrier. Limitations of present designs have been described previously. Each would have certain advantages. For example, the mechanical type floating barrier could be more readily installed at any of the possible inlets. Therefore, its portability and relative flexibility in length make it more versatile for possible use at any inlets from a central storage point. Certainly, if the offshore spill is 25-30 miles from shore, time will be available to chart the movements of the slick and prepare shoreline defenses as is currently done for hurricanes. On the other hand, pneumatic barriers may be permanently installed across the major navigation inlets; their primary advantage lies in permitting an uninterrupted ship movement to continue until the oil endangers the coastlines. At present, no inlet protection systems of this type exist in U.S. waters.

When oil comes ashore, pronounced economic and ecological damages usually result. In many cases of offshore spills, complete removal or dispersal of the oil will be impossible and, therefore, methods and procedures for beach restoration must be available. When a spill occurs and oil washes ashore, it accumulates along the shoreline and may contaminate vessels and shore installations. On beaches, the main impact is aesthetic and the immediate remedy is physical removal of the oil-contaminated sands.

Oil contamination of beaches usually causes one or both of the following situations. (1) Beach material becomes uniformly contaminated

with a thin layer of oil up to the high tide mark and/or deposits of oil dispersed randomly over the beach surface. Oil penetration is usually limited to approximately one inch, unless dispersants have been used. (2) Agglomerated pellets of oil-sand mixture or oil-soaked material, such as straw and beach debris, distributed randomly over the surface and/or mixed into the sand.

Beaches can be cleaned by several techniques. The use of straw on the beach after oil reaches the shore is generally not very effective. However, if the straw is spread before the oil has a chance to reach the shoreline, then it is more effective in absorbing oil and minimizing the amount which penetrates into the sand.

At Santa Barbara, several techniques were tried in rocky areas, including stream cleaning, sand blasting and high-pressure water streams. Sand blasting was the only one found to be totally effective; however, this method is slow and costly, requiring extensive use of hand labor to remove accumulated debris.

Other cleanup techniques used at Santa Barbara included:

- Vacuum tank trucks, of the type used in cleaning out septic tanks; they were used to recover accumulated oil from Santa Barbara Harbor.

- Straw mulchers or spreaders which were used to distribute the sorbent materials.

- Road graders, with tines welded below the blade, which were used for raking debris.

- Bulldozers, front-end loaders and dump trucks used for picking up and hauling away accumulated debris.

The restoration of beaches involves:

- Physical pickup and removal for disposal of oil deposits, oil-soaked sand, straw and other debris, cleaning of the

sand on the beach through removal by screen separation of contaminated materials, and,

Disposal of contaminated materials at an approved site.

The choice of restoration methods depends upon the economic and recreational value of the area and the urgency of returning the area to "normal" conditions. A highly-developed resort complex, where a large proportion of the area economic activity depends upon retaining the attractiveness of the beach, will require implementation of cleaning methods chosen more for their quickness than for their cost. In other instances, where the shoreline is mainly valued for its view, the presence of contaminants on the beach will not be so critical and restorative techniques of a slower, less costly nature will be found adequate.

2. CHEMICAL SPILL CONTROL AND CLEANUP

In the event of a chemical discharge or leak, efforts are made to reduce, stop, or contain the flow of material at its source in a safe manner.

The Manufacturing Chemists Association operates a Chemical Transportation Emergency Center (CHEMTREC) 24 hours a day to handle emergency situations arising from spills of bulk liquid chemicals. One can consult experts on chemicals and spill response by calling the appropriate CHEMTREC toll-free number.

The Coast Guard has a Chemical Hazard Response Information System (CHRIS) which is designed to provide information needed for decision-making by responsible Coast Guard personnel during emergencies that occur in the transportation of hazardous chemicals. CHRIS consists of handbooks or manuals, a hazard assessment computer system and technical support personnel located at Coast Guard headquarters.

The Coast Guard's Regional Contingency Plans, although not considered a part of CHRIS, are an important adjunct to the system. Each Regional Contingency Plan contains a section that presents data on a specific

region, sub-region, or locale. These data, which are intended for use by On-Scene Coordinator personnel, include the following information:

- An inventory of physical resources and strike forces
- Vulnerable or exposed resources
- Potential pollution sources
- Geographical and environmental features
- Cooperating organizations
- Recognized experts with identified skills

The Coast Guard's National Strike Force consists of personnel especially trained and equipped to respond to discharges of oil and hazardous materials. It is organized into three strategically located teams, the Pacific, the Atlantic, and the Gulf strike teams, consisting of approximately three officers and 15 enlisted men per team. Each team maintains a state of readiness that enables a minimum of four men to proceed to a pollution incident within two hours of notification with augmentation up to full team strength within 12 hours. The National Strike Force has been involved in salvage and cargo transfer operations on vessels ranging in size from small inland barges to tankers and very large crude carriers.

The Environmental Protection Agency's Division of Oil and Hazardous Materials provides emergency assistance on procedures for safe handling and cleanup of the spilled chemicals. In a matter of minutes, all pertinent information and details can be given with the aid of the OHM-TADS (Oil and Hazardous Materials Technical Assistance Data System). Interrogation of an on-line computerized data bank provides a print out which is immediately checked by a spill-response expert and relayed to cleanup personnel. The OHM-TADS techniques and equipment are fairly recent innovations which are being utilized and improved to provide a data network for emergency service to spill response personnel all over the nation.

F. RECENT AND FUTURE PROGRAMS

1. LEGISLATIVE PROGRAMS

The most recent emphasis on the mitigation of marine pollution as a result of waterborne commerce within the federal government can be summarized by the Presidential Message to the Congress on March 17, 1977, the Amendments to the Ports and Waterways Safety Act of 1972, and the National Oil Pollution Liability and Compensation Act of 1977. Both of the congressional acts are currently being reviewed in Senate committees.

The Presidential Message to the Congress recommended the formulation of regulations for all new tankers which would include: double bottoms, segregated ballast, inert gas systems, backup radar systems and collision avoidance radar systems, improved steering standards, and improved crew standards for all new tankers. The President also requested the development of a tanker boarding program, formation of a marine safety information service, approval of comprehensive oil pollution liability and compensation legislation, improvement of the federal ability to respond to oil pollution emergencies, and Senate ratification of the International Convention for the Prevention of Pollution from Ships.

The programs delineated in the Presidential Message are principally incorporated into Senate Bill 682 the "Tanker Safety Act of 1977", and Senate Bill 687 the "National Oil Pollution Liability and Compensation Act of 1977". The Tanker Safety Act of 1977 amended the Ports and Waterways Safety of 1972. The purpose of the act is to: (1) authorize a comprehensive inspection and enforcement program; (2) establish stringent standards for the design, construction equipment maintenance, alteration, repair, operation and manning of vessels which use U.S. waters; and (3) establish a program to prevent any substandard vessel from operating in the navigable waters of the United States.

The National Oil Pollution Liability and Compensation Act of 1977 is being enacted to provide a comprehensive national law governing oil pollution liability and compensation and the creation of an all exclusive compensation fund to pay for damages and cleanup compensation and restoration costs due to oil discharges.

In May 1977 the Coast Guard, in response to the Presidential instructions, published proposed rules for new construction and equipment standards for oil tankers. The new rules would apply to all U.S. and foreign tankers over 20,000 deadweight tons, which enter U.S. waters. A radar equipment requirement would apply to all vessels over 10,000 gross tons. The proposed regulations would require:

- Double bottoms on new tankers, and segregated ballast capability on both new and existing tankers to reduce oil spillage in U.S. waters;

- Improved emergency steering standards on all tankers to reduce the probability of collision and grounding of oil tankers caused by steering failure and therefore reduce the risk of oil pollution.

- Inert gas systems on all tankers to reduce the number of cargo tank explosions on board tankers.

- Backup radar systems with collision avoidance equipment on all vessels of over 10,000 gross tons to reduce the probability of collision and grounding of oil tankers and therefore the risk of pollution.

The other Presidential instructions relating to measures for improved crew standards, tanker boarding programs and information systems, ratification and implementation of the International Convention for the Prevention of Pollution from Ships; and approval of comprehensive oil pollution liability and compensation legislation are under development by the Coast Guard and other federal organizations.

2. IMCO PROGRAMS

IMCO convened an International Conference on Tanker Safety and Pollution Prevention in London, England on February 6-17, 1978 in response to the President's Message to Congress. The outcome of the IMCO Conference was the adoption of Amendments to the 1974 International Convention on

Safety of Life at Sea (SOLAS) and the 1973 Convention on the Prevention of Pollution from Ships (MARPOL). The new requirements are as follows:

a. SOLAS PROTOCOL

- Improved inspection and certification procedures for all ships.
- Inert gas systems for all new tankers 20,000 DWT and above and existing tankers of 40,000 DWT or more.
- Second radar on all ships over 10,000 GRT. IMCO will also prepare a performance specification for collision avoidance aids by July 1979.
- Improved emergency steering gear requiring two independent steering control systems for all tankers 10,000 GRT or more.

b. MARPOL PROTOCOL

- Protective location of segregated ballast tanks in the side and bottom shell areas for new tankers.
- Clean ballast tanks as an alternative to segregated ballast on product tankers by using certain cargo tanks only for clean ballast water.
- Crude oil washing for tankers 20,000 DWT and over and as an alternative to segregated ballast for existing crude oil tankers of 40,000 DWT and above.

Since human error accounts for 80 to 85 percent of all marine accidents, President Carter, in his message, also strongly recommended that IMCO consider improvement of crewing standards at its forthcoming International Conference on Training and Certification of Seafarers. The conference is scheduled to be held in London in June 1978.

3. OIL POLLUTION ABATEMENT PROGRAMS

MarAd completed a study of programs conducted by the U.S. Coast Guard, Navy, Army Corps of Engineers, EPA and the Maritime Industry which covered a broad range of tanker features relating to pollution abatement (6). The pollution abatement features studied were:

- Hull design and construction
- Ship propulsion and maneuverability
- Safety of navigation
- Pollution abatement systems and equipment
- Crew standards and training
- Comprehensive oil pollution liability and compensation
- Reception facilities in port for treatment of oily wastes from ships
- MarAd pollution abatement research and development programs
- Presidential initiatives dealing with marine oil pollution

The pollution abatement features studied were assessed in relation to the President's Message to Congress. The study concluded that certain features appear at least equal to the Presidential initiatives. These features are shown in Table V-5 under pollution abatement techniques and are categorized according to their application to new vessels (only) or new and existing vessels.

Because the installation of double bottoms on new tankers and segregated ballast on new and existing tankers can be a costly venture, some consideration will be given to alternate methods of reducing operational and accidental pollution from vessels. The Coast Guard regulations allow the acceptance of technical improvements or alternate design or equipment as "equivalent" to segregated ballast and double bottoms. Possible alternatives to segregated ballast for tank vessels include:

- Crude oil washing
- Ballast oil/water separator
- Shoreside facilities

Possible alternatives to double bottoms for tank vessels include:

- Defensive location of segregated ballast
- Intermediate cargo tank deck

The intermediate deck concept has yet to be demonstrated as an effective method of preventing pollution and requires further study to determine whether or not it is a viable alternative.

Table V–5
POLLUTION ABATEMENT ALTERNATIVES

POLLUTION ABATEMENT TECHNIQUES	CURRENT OR PROPOSED USCG REGULATION	DESCRIPTION
NEW VESSELS (ONLY)		
O USCG SEGREGATED BALLAST (DEFENSIVE LOCATION)	YES	O BALLAST WATER CONTAINED IN TANKS SEPARATE FROM CARGO OIL TANKS (OIL, DOUBLE BOTTOM, DOUBLE HULL, ETC.)
O IMPROVED RUDDER AREA/RUDDER RATE	NO	O INCREASED RUDDER SIZE AND/OR INCREASED RUDDER TURNING RATE. LARGE RUDDERS ON BIGGER TANKERS AFFORDS GREATER MANEUVERABILITY.
O INTERMEDIATE CARGO TANK DECK	NO	O CONSISTS OF FITTING AN INTERMEDIATE WATERTIGHT DECK WITHIN CARGO TANK NEAR WATERLINE. ACCIDENTAL OIL SPILLS FROM GROUNDING ACCIDENTS ARE REDUCED BECAUSE PRESSURE HEAD TO FORCE OIL OUT OF TANK IS ELIMINATED.
NEW AND EXISTING VESSELS		
O TUG ASSISTANCE	YES	O REQUIRES AN ADDITIONAL TUG TO BE USED IN RESTRICTED WATERWAYS WHEN MANEUVERING; PROVIDES AN ADDED MARGIN OF SAFETY AGAINST ACCIDENTS.
O MANEUVERING BOOKLET	NO	O PROVIDES SHIP OFFICERS AND PILOTS WITH USEFUL INFORMATION ABOUT THE MANEUVERING CAPABILITIES OF THE VESSEL.
O LORAN C	YES	O AN ELECTRONIC NAVIGATIONAL SYSTEM THAT PROVIDES ACCURATE VESSEL POSITIONS AND AVOIDS COLLISIONS AND GROUNDINGS.
O RADAR	YES	O AN ELECTRONIC DEVICE THAT PROVIDES AN ACCURATE METHOD OF OBTAINING BEARINGS AND DISTANCES IN ALL CONDITIONS OF VISIBILITY.
O DOPPLER SPEED DEVICE	NO	O SONAR DEVICE THAT DETERMINES SHIP SPEED IN WATER BY MEASURING RELATIVE CHANGE IN THE FREQUENCY OF SOUND WAVES REFLECTED FROM WATER TO A MOVING SHIP. ACCURATE SOURCE OF SPEED INFORMATION FOR COMPUTERIZED COLLISION AVOIDANCE SYSTEMS AND DOCKING SYSTEMS.
O LOAD ON TOP	YES	O BALLAST WATER IN CARGO TANKS IS PERMITTED TO SETTLE THEN PUMPED OVERBOARD. THE REMAINING OILY BALLAST AND WASH WATER IS TRANSFERRED TO A SLOP TANK, WHERE WATER IS DISCHARGED AFTER SETTLING. FRESH CARGO OIL IS LOADED ON TOP OF RESIDUAL OIL LEFT IN SLOP TANK.

Table V–5 (Cont'd.)

POLLUTION ABATEMENT TECHNIQUES	CURRENT OR PROPOSED USCG REGULATION	DESCRIPTION
NEW AND EXISTING VESSELS (Cont'd.)		
O BILGE OIL/WATER SEPARATOR	YES	O USUALLY A CENTRIFUGE SYSTEM THAT IS DESIGNED TO SEPARATE OIL FROM OILY BILGE WATER BEFORE DISCHARGING BILGE WATER OVERBOARD.
O BALLAST OIL/WATER SEPARATOR	NO	O HIGH CAPACITY OIL/WATER SEPARATOR DESIGNED TO HANDLE DEBALLASTING RATE OF VESSEL. TANK WASHING SLOPS CAN BE PROCESSED. EFFLUENT OIL CONTENT OF 15 ppm OR LESS IS POSSIBLE.
O CRUDE OIL WASHING	NO	O CRUDE OIL WASHING DISSOLVES RESIDUES, WAXES AND CLINGAGE IN OIL TANKS.

a. SEGREGATED BALLAST AND DOUBLE BOTTOM ALTERNATIVES

The following is a brief description of the segregated ballast and double bottom alternatives:

(1) Crude Oil Washing-An Alternative to Segregated Ballast. The problem of mixing oil and water by employing the traditional method of washing cargo tankers with jets of water can be eliminated by washing the tanks with crude oil. During crude oil washing, a portion of the cargo oil being discharged ashore is diverted into the tank cleaning system and into the tanks being offloaded so that exposed tank internal surfaces coated with residual oil are washed by jets of crude oil. The solvent action of the crude oil dissolves sludge, paraffins and heavy asphaltic oils and leaves only a thin film of oil. A minimum amount of water washing is required for the tank to be used for clean ballast or gas freeing operations. Crude oil washing is economically attractive because: there is greater oil recovery, reductions in time and cost from routine drydock tank cleaning, and increased cargo oil capacity because less oil is retained onboard. Ultimately, crude oil washing will offer the capability of taking on ballast water without water washing and discharging clean ballast having an oil content of 15 ppm or less.

(2) Ballast Oil/Water Separator-An Alternative to Segregated Ballast. Ballast oil/water separators have not been widely used for primary shipboard processing of dirty ballast and tank washing slops. Suitable units for marine service with capacity to process the entire quantity of ballast on large tankers have not been available. However, manufacturers of oily water separators have recently demonstrated the ability to effectively process a wide variety of oil-in water mixtures with throughputs up to 3,000 gpm. The quality of the effluent would allow a tanker to be able to meet the permissible discharge requirements (no visible sheen or 15 ppm) in prohibited areas. An oily water separator used in conjunction with crude washing should provide at least equivalent, and possibly greater environmental protection than segregated ballast.

(3) Shoreside Reception Facilities-An Alternative to Segregated Ballast. Pollution from vessel operations can be eliminated by specific tanker design requirements or, alternatively, by requiring all ship's wastes to be retained onboard and discharged to shoreside treatment facilities. The installation of shoreside reception facilities for the treatment of oily wastes from ships would eliminate the need for tankers to discharge oily wastes at sea. The International Convention for the Prevention of Pollution from Ships, 1973, states that the government of each party to the convention shall ensure the installation of reception facilities at oil loading terminals, repair ports, and other ports in which ships have oil residues to discharge.

(4) U.S. Coast Guard Defensive Location of Segregated Ballast-Alternative to Double Bottoms. Current U.S. Coast Guard regulations on the defensive location of segregated ballast for new tankers of 70,000 DWT and above require that 45 percent of the cargo portion of the hull be protected by ballast tanks. Double bottoms or double sides can be used as a practical means to meet this requirement. On smaller vessels, the defensive requirement can be met economically by allocating wing tanks for segregated ballast. This design feature offers substantial bottom protection and also can provide protection in the case of side damage. The Segregated Ballast regulation requires that a given area of the shell be protected by ballast volumes or voids under penalty of forced reduction of allowable oil outflows. For example, segregated ballast spaces must be distributed so that the mathematical average of the hypothetical collision and stranding outflows as determined by the procedures in the regulations is 80 percent or less of the maximum allowable outflow.

(5) Intermediate Deck-An Alternative to Double Bottoms. The intermediate deck concept consists of fitting a watertight deck within the cargo tank near the waterline. The pressure head on the cargo in the lower tanks would be reduced or could be made slightly negative. In the event of grounding, outflow would be prevented or greatly minimized because of the lack of a pressure head on the liquid cargo in the affected cargo compartment. There would also be little change in vessel buoyancy.

Unlike the double bottom which will prevent outflow in only low energy groundings, the intermediate deck concept will prevent or minimize outflows in low, medium, and high energy groundings.

4. COMPREHENSIVE OIL POLLUTION LIABILITY AND COMPENSATION PROGRAMS

The Maritime Administration has supported the development of a comprehensive legal regime providing for liability and compensation for damages resulting from oil pollution incidents. The currently existing maze of state, federal and international laws is simply not conducive to rapid and fair compensation for damages. Comprehensive liability and compensation legislation would provide the needed protection to the public for oil pollution damages would assure rapid cleanup and restoration of the environment subsequent to an oil spill, and would serve as an incentive to prevent oil spills. The liability and compensation process would involve certain major steps: the oil discharge; the cleanup and removal; an investigation and report by an on-scene coordinator; a public notice regarding the appropriate claims procedure; an assessment of damages; the filing of claims; and the settlement and adjudication of claims.

MarAd has considered the goals of methods and procedures for administering this comprehensive system of liability and compensation(6). The goals may include the following:

- Encouragement of equality of treatment among claimants (a claimant may not be subject to a different standard because of spill location).

- Encouragement of uniform standards for damage measurement and assessment so as to assure full and fair compensation.

- Settlement and adjudication may be made as uncomplicated as possible to avoid unnecessary confusion and delays and to reduce costs.

Claimants and dischargers may have the choice of having their rights determined through judicial action or administrative action.

The concepts and provisions to accomplish these goals are outlined in detail in reference 5.

5. POLLUTION ABATEMENT RESEARCH AND DEVELOPMENT PROGRAMS

The Maritime Administration's research and development program for the prevention and control of pollution from ships was begun in 1962 subsequent to the passage of the 1961 Oil Pollution Act. This act implemented the 1954 International Convention for Prevention of Pollution of the Seas by Oil. In terms of priorities, the major program emphasis has been on the development of systems and procedures for reducing the quantities of ship-generated pollutants discharged both accidentally and intentionally. At the same time, means for the handling and disposal of ship-generated wastes have been investigated. MarAd has cooperated with other federal agencies, each of which has recognized the severity of the problem of preventing and controlling pollution from ships and has a major research and development program underway aimed at protecting the marine environment.

MarAd's research and development programs are structured to develop and apply advanced technology to improve the productivity and capabilities of the American shipping and shipbuilding industries. Although the pollution program is not directly aimed at improving the competitive position of the U.S. Merchant Marine, it has received a high priority within the overall research and development effort.

a. PAST RESEARCH AND DEVELOPMENT ACTIVITIES

The following is a brief description of past pollution prevention and control activities supported by the Maritime Administration. Two basic approaches were implemented; (1) the development of applied technology to enable ships to operate pollution-free and (2) the conduct of studies addressing the scientific, environmental, and economic aspects

of pollution-free ship operations. Within this basic framework, various project categories were established as follows:

(1) Onboard Processing. These projects were aimed at the improvement of onboard operations to reduce polluting discharges, such as:

(a) development of high capacity, oil/water separation systems, including instrumentation to monitor discharges;

(b) improvement of Load-on-Top operations by development and/or investigation of:

- oil/water interface detection equipment,
- ballast water contaminant levels,
- chemical flocculants to accelerate gravity separation of dispersed oil in water,
- improved slop tank design;

(c) evaluation and development of improved tank cleaning techniques and related operations, e.g., crude washing, sludge removal and disposal, and training guidelines;

(d) evaluation of ship stack gas monitoring methods and equipment;

(f) safety enhancement analyses for tankers concerning such topics as tank electrostatics, tank washing, and atmosphere control.

(2) Ship Design and Equipment. These projects investigated whether changes to the basic ship design and equipment offer potential for reducing oil discharges and evaluate the cost-effectiveness of each change. Studies of various tank arrangements for segregated ballast have been completed, and the costs, effectiveness, and operations associated with segregated ballast evaluated. In addition, developmental efforts have been pursued in the prevention of accidental oil spillage through advanced anti-stranding sonar systems, satellite communication and navigation systems, harbor advisory control systems, and the Computer Aided Operations Research Facility (CAORF).

(3) Shoreside Reception Facilities. Investigations have been performed regarding the design and economic requirements for collecting, processing, and disposing of ship generated wastes.

(a) Mobile Waste Oil Processing Vessel - studied the techno-economic feasibility of converting reserve fleet vessels into oily waste processing ships and sewage treatment ships for in-port use;

(b) Port Collection and Separation Facilities - determined the technical and economic requirements for establishing the capability in each port to collect, process, and dispose of all ship-generated oily wastes.

(4) Environmental Sciences. Long-range scientific studies were performed in order to establish an estimate of quantities and concentrations of intentional discharges of oil which can be safely tolerated by the marine environment. Such projects included the following:

(a) Source Quantification - This project aimed at helping to completely define the problem of oil pollution of the oceans by reliably pinpointing the sources of oil input as well as the areas of the oceans heavily loaded by either natural seepages or land outfalls. Such information is also helpful in determining rates of degradation and dispersion at various input concentrations.

(b) Ocean Mapping - A surface and sub-surface sampling project was sponsored in order to establish a baseline of hydrocarbon content in the oceans. This project resulted in the generation of worldwide oil pollution maps from which an understanding of the fate of the oil in the seas can be analyzed.

(c) Ship Discharges - A survey was conducted to define and quantify discharge sources originating from oil tankers operating under routine conditions.

(d) Stack Gas Emissions - A mathematical diffusion study was performed to determine the effect of ship stack emissions on air quality in the Port of Galveston.

(5) Pollution Control Regulations and Standards. Various studies have been performed in order to analyze the significance and effects of certain vessel discharges, regulations and standards applicable to these discharges, and available methods and processes for meeting the regulatory requirements. Such studies include the following:

(a) Shipboard sewage regulations and disposal methods;

(b) Regulations, significance, and control methods concerning stack gas emissions from oceangoing ships;

(c) Regulations concerning the transport of oil by inland tank barge.

b. PRESENT RESEARCH AND DEVELOPMENT ACTIVITIES

In recent years MarAd has reduced its support for the development of onboard processing equipment for preventing polluting ship discharges. Efforts have continued, however, on the development and application of advanced concepts for improving vessel operational safety and thereby reducing accidental pollution from ships. Projects being investigated and systems undergoing development include:

(1) Low cost satellite navigation and systems.

(2) Computer Aided Operations Research Facility (CAORF) to analyze and improve the human factor element of ship navigation and pilotage.

(3) Reliability of steering gear systems for high powered ships.

(4) Integrated lookout system to provide the vessel's conning officer with comprehensive threat information related to vessel safety.

(5) Harbor simulation model to study the ship/harbor interaction with a view to improving overall harbor design, channels and navigation, vessel traffic systems, and ship design.

(6) Advanced display concepts for standardized conning stations.

(7) Advanced collision avoidance system.

(8) Anti-stranding sonar systems.

(9) Bulk carrier operation safety enhancement.

c. FUTURE RESEARCH AND DEVELOPMENT ACTIVITIES

Future MarAd environmental R & D efforts will be part of a pollution control program plan which is directed at two primary goals as follows: (1) to significantly reduce the number and severity of merchant ship casualties which result in polluting discharges and (2) to significantly reduce the quantities of pollutants spilled, dumped, or discharged during routine merchant ship operations. Additional tasks to those listed previously for achieving these goals are as follows:

(1) Collection and analysis of ship (tanker) casualty data in order to determine cause and effect relationship of casualties.

(2) Establishment of physical and operational risks for tankers on selected routes and development of procedures and methodologies for lessening these risks.

(3) Improving maneuverability and stopping characteristics of tankers, particularly VLCCs.

(4) Improvement and simplification of inert gas systems for all tankers.

(5) Analysis and application of crude oil washing techniques.

(6) Evaluation of design, construction, and equipment standards for tank barges which carry oil.

(7) Improving procedures aboard ship for handling oil and hazardous chemical cargoes.

(8) Development of shoreside reception facilities for shipboard wastes.

Detailed outlines of some of the more important aspects of these projects, both current and planned, are described in reference 5.

d. FUTURE CREW STANDARDS AND TRAINING

The present training provided in maritime training institutions has generally proven to meet operational needs. There are however, significant areas where future improvements in training have been recently discussed. The area of most immediate concern is as a result of the recent series of oil tanker accidents. Certain regulatory measures which will increase the demand on existing training capabilities have been recommended.

MarAd is requesting additional funds and positions to expand its maritime training capabilities in consonance with the proposed regulatory measures. This expansion is briefly described as follows:

(1) Augment existing Collision Avoidance Radar equipment and staff at MarAd's Regional Radar Training Centers.

(2) Add two new Collision Avoidance Radar Training Facilities.

(3) Add staff and equipment to expand MarAd's LORAN-C training program.

(4) Participate jointly with Coast Guard in a study to establish effective training and examination evolutions with Ship Handling Simulators.

(5) Develop an approved training course in pollution prevention, control and abatement; including curriculum handbook and training devices.

Improvements have also been discussed in providing assistance to maritime training institutions. It has been proposed that authorization be provided to the Secretary of Commerce to make available marine equipment which is surplus to the needs of the Maritime Administration and which can be used as training aids at approved, non-profit maritime training institutions, without cost to the government. This proposal requires legislation and further study by MarAd.

Another area of concern involves the training of entry ratings. It has been recently proposed that applicants for original certificates of service be required to satisfactorly demonstrate basic knowledge and skills via training and examination. This proposal would require a legislative amendment and is currently being reviewed by the U.S. Coast Guard. The topic has also been recognized and discussed at IMCO. An IMCO draft recommendation provides that every prospective seafarer should receive training prior to seafaring employment.

Finally, it should be noted that "Curriculum Standards for Merchant Marine Officers Training Programs" are currently being developed by the Office of Maritime Manpower with assistance from leading maritime training institutions. These standards will provide criteria to assist in evaluating programs which relate to the training of Third Mates and Third Assistant Engineers - Unlimited, for original licenses.

Examination and certification of merchant vessel personnel are within the jurisdiction of U.S. Coast Guard. A number of major changes are being discussed. The most significant change will be in three separate areas where regulations are to be amended. The areas are as follows:

(1) More emphasis will be placed on requiring deck officers to demonstrate important skills, such as radar operation and interpretation, instead of relying on written examinations.

(2) Requirements for issuance and renewal of licenses to ship masters, mates and federally licensed pilots, will include experience by class and size of vessel, or training and demonstration of proficiency on ship simulators.

(3) Regulations will be issued to require that crew members in charge of cargo transfer operations be specially trained and examined.

Coast Guard is currently developing Proposed Rulemakings to promulgate the regulations required by Items 1 and 2 above. The regulations required by Item 3 are contained in U.S. Coast Guard Proposed Rulemakings entitled, "Tankerman Requirements," which was published in the Federal Register of April 25, 1977.

CHAPTER V - REFERENCES

1 Final Opinion and Order of the Maritime Subsidy Board Docket A-75, MarAd Tanker Construction, August 30, 1973.

2 Final Opinion and Order Docket A-93 On The MarAd Bulk Chemical Carrier Construction Program, December 31, 1974.

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6 Oil Transportation By Tankers: An Analysis of Marine Pollution and Safety Measures, Congress of the United States, Office of Technology Assessment, July 1975.

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CHAPTER VI

ALTERNATIVES TO THE DOMESTIC TANK VESSEL - TITLE XI PROGRAM

The Maritime Administration has the federal responsibility to provide technical and financial assistance to the U.S. maritime industry. To discharge this responsibility the Maritime Administration has established five principal programs to economically promote the maritime industry. These programs as illustrated in Figure VI-1 have a common goal but utilize different funding mechanisms. As illustrated in the figure, the Title XI program for domestic bulk waterborne commerce, the subject of this environmental assessment, is only a portion of the overall Title XI program which, in turn, is only one of the five financial programs administered by the Maritime Administration. Although the specific methodology of providing the funding to industry is different within the respective programs, the common goal of promoting the maritime industry is the same. It would be erroneous to consider the remaining four programs as alternative programs in the event the Title XI funding were curtailed. The Merchant Marine Act of 1936, as amended (the Act), prohibits the payment of Operating Differential Subsidy (ODS) to any person or company engaged in domestic trade. The Act also requires a Construction Differential Subsidy (CDS) applicant to build his ship for use only in the foreign commerce of the U.S. Finally, the Capital Construction Fund (CCF) program is not available to operators operating vessels only in the contiguous domestic commerce. Therefore, the decrease or cessation of Title XI funding would not leave the range of alternative types of funding available to domestic operators as implied in Figure VI-1. The curtailment of the Title XI program would deny the Maritime Administration the flexibility of providing the maritime financial assistance and would make overall program administration more difficult.

The alternatives range from the discontinuance or suspension of the Title XI financial aid program, to the requirement for improved construction and pollution standards to reduce potential pollution from vessels under this program.

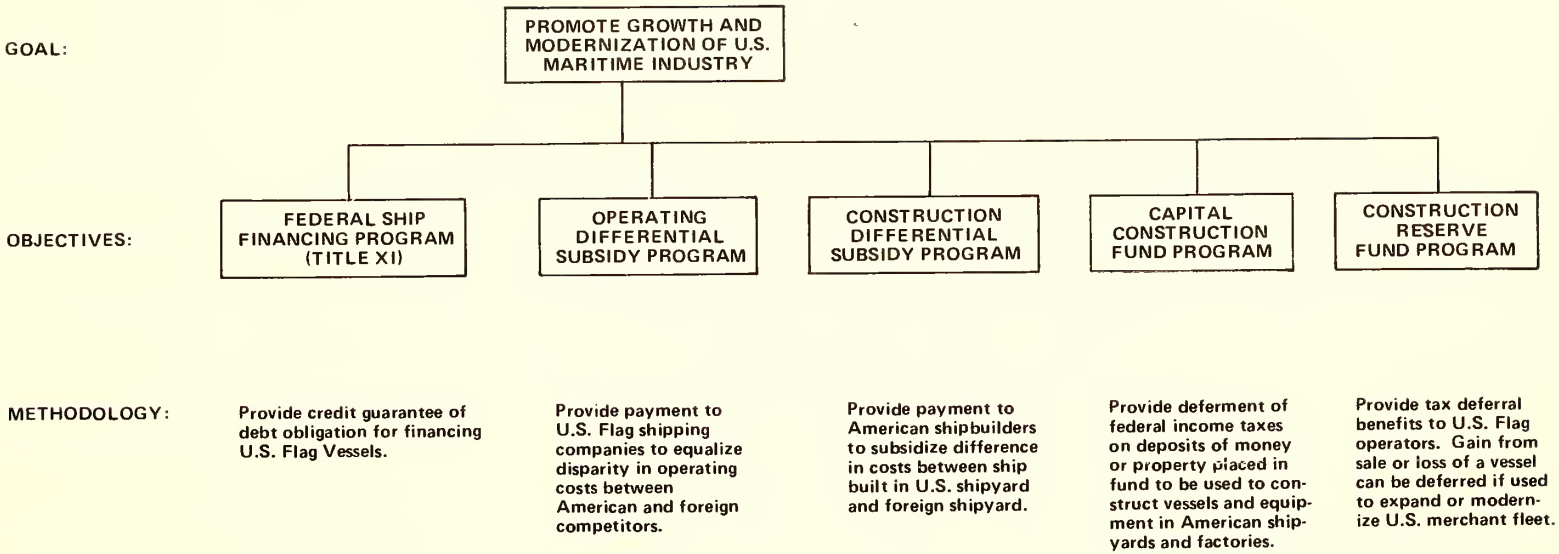

Figure VI–1 MarAd FINANCIAL ASSISTANCE PROGRAMS FOR U.S. MARITIME INDUSTRY
SOURCE: U.S. Maritime Administration, 1978.

A. DISCONTINUE THE PROGRAM

An alternative available to the Secretary of Commerce is to discontinue this assistance to tankers (oil and chemical) and tank barges. Such an action would violate the intent of the Jones Act and the Merchant Marine Act of 1936, as amended in 1970, to promote the U.S. - merchant marine fleet for economic and national defense purposes. By discontinuing MarAd Title XI assistance to these tanker and tank barge programs, some construction of privately financed American vessels would stop and the rate of U.S. shipbuilding would decline. At a time when the need for the transportation of energy products is critical, the elimination of the Title XI program would only result in the adverse economic impact. If the Title XI program for U.S. tankers engaged in domestic trade is discontinued, the U.S. would be expected to become more dependent on the importation of oil. For example, an alternative that has been given serious consideration by the Department of Energy (DOE) is to export Alaskan oil to Japan and import Middle Eastern oil to the U.S., instead of employing U.S. tankers to transport Alaskan oil to California ports for trans-shipment to the Gulf and East Coast refineries (1). If DOE's alternative is implemented, the incident rate of oil spills would be expected to increase because it has been demonstrated that foreign flag vessels are more spill prone in U.S. waters than U.S. vessels (refer to discussion of Spill Probability and Risk of Chapter IV).

The enforcement of environmental controls is a major problem with foreign vessels. Hence the substitution of foreign flag tankers for U.S. constructed, owned, operated and regulated vessels would involve increased risks of pollution of U.S. waters and shoreline. Such risks are difficult to quantify because it is difficult to predict the flags of the vessels which might be used in U.S. trades, the stringency of inspection and regulation of the vessels, the qualifications of their crews, and other variables. Enforcement of the 1973 IMCO Marine Pollution Convention Vessel standards for pollution abatement has yet to be fully demonstrated by individual countries.

Termination of the Program would reduce the amount of materials used for construction, lessen shipyard generated pollution and may substantially reduce the pressure for expansion of U.S. shipyard facilities. An analysis of the environmental benefits which may flow from this alternative must be judged in terms of the alternative activities which could take place in shipyards and elsewhere if tanker and barge construction were halted. Most shipyards could be expected to continue to construct naval and other types of merchant ships. Complete elimination of the Program would have the effect of reducing the availability of vessels of the highest construction and operational standards to transport oil and chemicals in U.S. waters.

The termination of this Program would, in addition to the above, have adverse implications for U.S. employment, U.S. economic status and our national defense posture which would rely heavily on these vessels during time of national crisis.

B. SUSPEND THE PROGRAM

Another alternative available to the Secretary of Commerce is to suspend this form of government assistance and await the technical improvements of tankers and barges so that the potential pollution is reduced.

It is the belief of the Maritime Administration that the design, construction and operational features of the U.S. vessels represent the highest level of practical pollution control that can be achieved. With the present state of the art it is doubtful where any additional pollution control features would prove to be environmentally, as well as economically, beneficial. However, this will not preclude the future installation of new features which have been proven to be beneficial as a result of MarAd, Coast Guard, Navy, and EPA on-going research and development efforts.

C. ALTERNATIVE MODES OF TRANSPORTATION (2)

The alternative modes of moving certain bulk liquid cargoes are: (1) pipeline, (2) railroad, (3) motor carriers and (4) aircraft. The following discussion provides a general comparison of these alternative modes.

By far the most competitive alternative mode of bulk liquid transportation to the tank vessel is by pipeline. While motor tank trucks and rail tankcars offer the advantage of speed and flexibility, these two modes lack the large capacity that can be achieved with tank vessels. As a result this large capacity advantage can be translated into a cost advantage achieved by tank vessels over trucks and trains. This is particularly true for oil and to a lesser extent for the movement of hazardous materials which are moved in smaller lots. Because chemicals are moved in these smaller lots trains and trucks become somewhat more cost competitive.

It can be concluded that movement by pipeline is generally the lowest cost, highest volume and least flexible of all modes of transportation.

The pipeline mode has three important advantages:

- The pipeline route is usually more direct than the marine route.
- The pipeline is suited to unbalanced "one-way" commodity flows. Balanced flow patterns are not necessary since the pipeline does not require the return of a vessel to the origin to be refilled.
- The pipeline has a very low variable cost. On a fully allocated cost basis, pipeline and marine costs may be approximately equivalent; however 70% of the costs of pipeline are fixed capital costs and variable costs are very low. Hence, it is much cheaper to operate a pipeline than a marine vessel, but it is much more expensive to build a pipeline than a marine vessel. However in light

of escalating construction costs and increases in pipeline property taxes, careful economic analyses are required to determine the true costs.

Additional advantages of the pipeline mode are its large capacity and its ability to vary the capacity of the operating system simply by changing the flow rate of the material being transported. The pipeline mode has the inherent ability to provide continuous and reliable movement of large volumes of bulk liquid commodities.

Inflexibility is the greatest disadvantage of the pipeline mode. Pipelines can offer direct service only to those shippers and receivers which are linked to the system. However, it should be noted that the handling cost of most materials transported by pipeline is very low and that the movements of these liquid commodities are generally efficient operations. Therefore, the pipeline can offer indirect service to a wide range of shippers and receivers.

Although the possibility exists for development of a liquid bulk air lift system, it does not appear to be a viable alternative at this time. Operation of a large fleet of air tankers that would be required to carry even a portion of domestic oil and chemical volume would involve substantial air and noise pollution and land changes.

As indicated above each mode of transportation has inherent capabilities and characteristics, i.e. flexibility, capacity, speed, which influence its role in the transportation system. A 1974 Study prepared for the Maritime Administration ranked each of the modes within each characteristic. While this study was performed for all types of commodities (dry and liquid) it can be used to show the qualitative ranking for the movement for oil and chemicals. (see Table VI-1)

Table VI–1
COMPARISON OF ALTERNATIVE MODES OF TRANSPORTATION

HIGH FLEXIBILITY	HIGH CAPACITY	HIGH SPEED	LOW COST
TRUCK	PIPELINE	AIRLINE	PIPELINE
RAIL	WATER	TRUCK	WATER
WATER	RAIL	RAIL	RAIL
PIPELINE	TRUCK	WATER	TRUCK
AIRLINE	AIRLINE	PIPELINE	AIRLINE

SOURCE: Domestic Waterborne Shipping, Market Analysis, prepared by A.T. Kearney, Inc., Management Consultants, for the U.S. Maritime Administration, February 1974.

D. ENVIRONMENTAL IMPACT (3)

The environmental impact of oil and chemical pollution from oil and chemical release from alternative modes of transportation is of a lesser magnitude. However, the location of a spill, from alternative modes of transportation, e.g., a tank truck accident spilling oil or chemicals on a major highway may be of a greater health or safety hazard. In 1976, 82 railroad spillages (incidents) occurred accounting for 269,440 gallons of material* spilled in and around United States waters. These incidents involved mainly tank cars rather than rail freight movements. This is indicated by the large number of gallons spilled for each incident. (i.e., 3,286 gallons per incident) The major spillages were oil, and were caused by 60 rail vehicle incidents (167,220 gallons). Of these 60 incidents, there were eleven tank leaks (83,000 gallons), one equipment failure (2,000 gallons), and one tank overflow (4,000 gallons). The remainder was a result of valve failure, personnel error and other incidents (3).

For the same year, motor carriers have had a greater number of incidents than rail vehicles; however, the percentage of volume released was nearly the same. In 1976 the U.S. Coast Guard indicated that there were 335 incidents in or around U.S. waters of highway vehicles (considered motor carrier for the purpose of this discussion) contributing 323,391 gallons of material discharged. Oil spillages from tank leaks accounted for 36 of the incidents amounting to 23,639 gallons. The remaining accidents were the result of improper equipment operation/handling (14 incidents/3,803 gallons), personnel errors (14 incidents/4,793 gallons), tank overflow (40 incidents/7,216 gallons), structural failure (6 incidents/ 3,882 gallons), valve failure (8 incidents/10,690 gallons), equipment failure (9 incidents/1,167 gallons), and other incidents.

*Material includes crude oil, gasoline, other distillate fuel oil, fuel oil, solvent, diesel oil, asphalt or residual fuel oil, animal or vegetable oil, waste oil, chemicals, other oil, other pollutants, etc.

In 1976 there were 653 pipeline incidents resulting in 4,530,094 gallons released. Of the 653 incidents, 393 (contributing 3,692,893 gallons) were the result of pipeline related ruptures or leaks of oil (3).

In the study prepared for the Maritime Administration entitled, "A Modal Economic and Safety Analysis of the Transportation of Hazardous Substances in Bulk" the following environmental conclusions were reached from a comparison study of 10 hazardous chemicals by various modes of transportation. Table VI-2 illustrates the relative effects of the movement of the hazardous materials. The conclusions of the study are:

- With exception of chlorine and benzene, the annual expected exposure associated with the transport of the chosen substances is lowest for the barge mode.

- The truck mode of transport, judged on an expected annual exposure basis, is as safe as the barge mode, and both barge and truck are substantially safer than rail for the ten case studies.

- Pipeline was considered applicable for only one chemical, anhydrous ammonia, and therefore it is not possible to make general statements relating to its safety.

- The barge mode of transport is apparently better inspected and regulated from a safety point of view than rail or truck.

While these figures represent emissions from all forms of freight movement (i.e., oil, containers, dry bulk), they do provide a relative indication as to the amount of emission that would be released from the movement of just oil and chemicals.

As might be expected, motor carriers are subject to increasingly regulated air pollution requirements whereas domestic ocean carriers and railroads are largely unaffected.

Table VI–2
ECONOMIC AND SAFETY COMPARISON OF TRANSPORTING SELECTED BULK CHEMICALS

CHEMICAL NAME ANNUAL TONNAGE HAZARDS	TRANSPORTATION MODE	LINE HAUL DISTANCE (Miles)	COMPLETE COST OF SHIPMENT (Per Ton)	RELATIVE EXPOSURE (PERCENT URBAN-(PERCENT RURAL)	SHORT-TERM ENVIRONMENTAL IMPACT DUE TO SPILL	RECURRENCE INTERVAL FOR SPILLS (Years)	RELATIVE HUMAN EXPOSURE INDEX[a]	EXPECTED ANNUAL VALUE OF PROPERTY LOSS (URBAN/RURAL)
ACRYLONITRILE ANNUAL TONNAGE SHIPPED: 80,000 TONS HAZARDS: FIRE AND WATER TOXICITY	BARGE	1,400	$7.50–8.50	8/92	12 ACRES FLAMMABILITY 3.6 MILES WATER TOXICITY	86	1.0	$ 130/55
	TRUCK	780	$40.00	23/77	1.1 ACRES	16	1.0	$ 160/20
	RAIL	770	$11.50	27/73	3.3 ACRES	6	14	$2400/250
	PIPELINE							
ANHYDROUS AMMONIA ANNUAL TONNAGE SHIPPED: 100,000 TONS OR MORE HAZARDS: TOXIC VAPOR AND WATER TOXICITY	BARGE	960	$8.73	15/85	7 ACRES LAND TOXICITY 1 MILE WATER TOXICITY	150[b]	1.0	$ 0
	TRUCK	808	$58.00–61.00	23/77	3 ACRES	14[b]	6.5	$ 0
	RAIL	837	$13.00–15.00	11/89	10 ACRES	22[b]	7.9	$ 0
	PIPELINE	700	$6.26	0/100	76 ACRES	2.6[b]	140	$ 0
BENZENE ANNUAL TONNAGE SHIPPED: 134,000 TONS HAZARDS: FIRE AND WATER TOXICITY	BARGE	26	$2.42	100/0	15 ACRES FLAMMABILITY 11 ACRES (WATER TOXICITY)	1000	1.0	$ 180/0
	TRUCK	26	$12.20	100/0	2 ACRES	500	0.17	$ 38/0
	RAIL	19	$7.00	100/0	5 ACRES	110	4.0	$ 780/0
	PIPELINE							
CHLORINE ANNUAL TONNAGE SHIPPED: 16,000 TONS HAZARDS: TOXIC VAPOR AND WATER TOXICITY	BARGE	440	$6.69	9/91	12,000 ACRES VAPOR 21 MILES WATER TOXICITY	9400[d]	1.0	$ 0
	TRUCK	418	N.A.[c]	10/90	150 ACRES	250[d]	0.52	$ 0
	RAIL	965	$23.00	13/87	380 ACRES	250[d]	1.6	$ 0
	PIPELINE							

Table VI–2 (Cont'd.)

CHEMICAL NAME O ANNUAL TONNAGE O HAZARDS	TRANSPORTATION MODE	LINE HAUL DISTANCE (Miles)	COMPLETE COST OF SHIPMENT (Per Ton)	RELATIVE EXPOSURE (PERCENT URBAN-(PERCENT RURAL)	SHORT-TERM ENVIRONMENTAL IMPACT DUE TO SPILL	RECURRENCE INTERVAL FOR SPILLS (Years)	RELATIVE HUMAN EXPOSURE INDEX [a]	EXPECTED ANNUAL VALUE OF PROPERTY LOSS (URBAN/RURAL)
ETHYLENE GLYCOL	BARGE	335	$3.65	16/84	0.04 MILES WATER TOXICITY	560	0	$ 0/0
ANNUAL TONNAGE SHIPPED: 100,000 TONS OR MORE	TRUCK	200	$27.00	16/84	0.2 ACRES	71	1.0	$ 20/4
HAZARDS: NUISANCE AND WATER TOXICITY	RAIL	290	$14.37	6/94	0. ACRES	18	3.3	$ 103/60
	PIPELINE							
METHANOL	BARGE	1,700	$6.88	15/85	12 ACRES FLAMMABILITY 0.3 MILES WATER TOXICITY	22	1.0	$ 960/200
ANNUAL TONNAGE SHIPPED: 350,000 TONS OR MORE								
HAZARDS: FIRE AND WATER TOXICITY	TRUCK	1,225	$62.00	21/79	1 ACRE	2.3	1.1	$1100/150
	RAIL	1,121	$37.00	16/84	4 ACRES	0.95	10	$9700/1900
	PIPELINE							
STYRENE	BARGE	1,500	$8.90–9.40	13/87	10 ACRES FLAMMABILITY 2.4 MILES WATER TOXICITY	35	1.0	$ 450/120
ANNUAL TONNAGE SHIPPED: 200,000 TONS								
HAZARDS: FIRE AND WATER TOXICITY	TRUCK	1,232	$56.00	24/76	1.3 ACRES	4.5	1.4	$ 700/84
	RAIL	1,035	$25.00	17/83	4.7 ACRES	1.1	24	$1100/2100
	PIPELINE							
SULPHURIC ACID	BARGE	8	$1.70	100/0	(e)	33,000[f]	1.0	$ 0
ANNUAL TONNAGE SHIPPED: 37,000 TONS	TRUCK	30	$4.40	100/0	0.22 ACRES	1,700	1.5	$ 5
HAZARDS: CHEMICAL DECOMPOSITION AND WATER TOXICITY	RAIL	30	$6.80	100/0	0.78 ACRES	590	15	$ 53
	PIPELINE							

NOTES: (a) THE RELATIVE HUMAN EXPOSURE INDEX IS A NORMALIZED ASSESSMENT OF THE RELATIVE NUMBER OF PEOPLE EXPOSED ANNUALLY TO SPILL HAZARDS ASSOCIATED WITH THE BULK MOVEMENT OF A CHEMICAL VIA ALTERNATIVE MODES OF TRANSPORTATION. FOR EXAMPLE, THE PROBABILISTIC INDEX FOR ACRYLONITRILE CAN BE INTERPRETED TO MEAN THAT IN THE PROCESS OF CONDUCTING THIS MOVE FOR EVERY 1 PERSON LIKELY TO BE EXPOSED TO BARGE SPILL HAZARDS, 1 PERSON IS LIKELY TO BE EXPOSED TO TRUCK SPILL HAZARDS AND 14 PERSONS ARE LIKELY TO BE EXPOSED TO RAIL SPILL HAZARDS.

Table VI–2 (Cont'd.)

NOTES: (b) IT SHOULD BE NOTED THAT THE STATISTICAL UNCERTAINTY ASSOCIATED WITH THE RECURRENCE INTERVAL IS GREATER FOR BARGE IN THIS CASE STUDY THAN IN THE OTHER CASE STUDIES (WITH THE EXCEPTION OF CHLORINE). AMMONIA BARGE AND TANK TRUCK CONSTRUCTION IS SUPERIOR TO THAT OF AN "AVERAGE" TYPE AND THE NATIONAL ACCIDENT STATISTICS USED IN DEVELOPING THIS NUMBER DOES NOT CREDIT THIS MOVE FOR USE OF SUPERIOR EQUIPMENT. SIMILARLY, THE STATISTICAL UNCERTAINTY FOR PIPELINE IS ALSO EXPECTED TO BE LARGE. DATA SPECIFIC TO THE PIPELINE THAT WAS USED WAS LIMITED TO ACCIDENT DATA ON A RELATIVELY NEW PIPELINE AND MAY NOT BE REPRESENTATIVE OF FUTURE TRENDS.

(c) COST FIGURES NOT AVAILABLE SINCE TRUCKS ARE NOT CURRENTLY USED.

(d) THE STATISTICAL UNCERTAINTY ASSOCIATED WITH THE RECURRENCE INTERVAL IS GREATER FOR BARGE AND TRUCK IN THIS CASE STUDY THAN IN THE OTHER CASE STUDIES (WITH THE EXCEPTION OF AMMONIA). CHLORINE BARGE AND TRUCK CONSTRUCTION IS SUPERIOR TO THAT OF AN "AVERAGE" TYPE AND THE NATIONAL ACCIDENT STATISTICS USED IN DEVELOPING THIS NUMBER DOES NOT CREDIT THIS MOVE FOR USE OF SUPERIOR EQUIPMENT.

(e) THIS MOVEMENT IS ENTIRELY WITHIN A HARBOR. THE EXTENT OF WATER POLLUTION WILL DEPEND ON WHEN IN THE TIDAL CYCLE THE SPILL OCCURS, THE PREVAILING WATER CURRENT AND POSSIBLY THE LOCAL SALINITY GRADIENTS. A MEANINGFUL ESTIMATE OF IMPACT WAS NOT POSSIBLE FOR THIS CASE.

(f) BASED ON ACCIDENTS IN RIVERS ON A NATIONAL AVERAGE BASIS.

SOURCE: Adapted from: A Modal Economic and Safety Analysis of the Transportation of Hazardous Substances in Bulk, prepared by Arthur B. Little, Inc., for the Maritime Administration, July, 1974.

Noise pollution from all modes of transportation is considered to have a minor impact, except possibly for air carriers which is not considered a viable alternative at this time. For example, the findings of the United States Railway Association in its Preliminary System Plan (5) indicate that the percentage of the United States population affected by noise pollution from all types of moving trains is extremely small. EPA's study entitled Transportation Noise and Noise-Equipment Powered by Internal Combustion Engines, states: "Of all the sources of noise in transportation systems, ships are probably the least important in terms of environmental impact on the community in general...(6)

E. NEW STANDARDS

Another alternative that could be implemented is to require new standards relating to tank vessel pollution abatement including construction design, equipment, personnel competence and operational features.

With the most recent Presidential Message to Congress recommending the formulation of pollution abatement regulations for oil tankers and the recent Senate Bills 682 and 687 (entitled: "The Tanker Safety Act of 1977" and "The National Oil Pollution Liability and Compensation Act of 1977"), with the promulgation of various Coast Guard regulations in response to the Presidential initiative, and with the guidance of the Maritime Administration's Policies and Vessel standard specifications, U.S. domestic tank vessels will be required to meet the most stringent safety and pollution control standards of any flag vessel in the world.

As new advances in pollution abatement are proven effective, environmentally as well as economically, through research and development efforts, they will be considered for implementation. However, it is believed at this time that the addition of new standards above and beyond those presently proposed or required would not appreciably improve the protection of the marine environment without substantial economic burdens.

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CHAPTER VII

ADVERSE ENVIRONMENTAL IMPACTS WHICH CANNOT BE AVOIDED UNDER THE PROGRAM

A. USE OF MATERIALS AND ENERGY RESOURCES

As indicated in chapter IV, the construction of vessels under this Program will require the use of quantities of steel, minerals, and energy resourses. While a very large part of the minerals can be recycled, the mining and processing of these materials may involve environmental harm in the form of land use-change and air and water pollution. However, when the amounts of materials used are considered in terms of total production and consumption, the amounts are small and ultimately recycled. In addition, it is questionable whether domestic production would be reduced, and hence the environmental effects reduced, if vessel construction under the Program did not take place. The expenditure of the energy resources necessary to produce the vessel construction materials and provide operating energy will be irretrievably lost in the pursuance of maintaining current productivity levels. The operation of these vessels will require the consumption of bunker fuel oil, diesel oil and lube oil. The extraction and processing of these products involve impacts generally similar to those concerning materials used in construction and other transportation systems. The amounts of materials and energy involved in the Title XI program vessels are small, and it is questionable whether the effect will be significant upon total national production and consumption.

B. ENERGY UTILIZATION

One of the major goals of the energy industry is the conservation of energy throughout the sequential stages from exploration to retailing. The efficient transportation of crude, finished products, and processed chemicals is an important aspect of the overall energy conservation program. It has been estimated that the petroleum industry consumes approximately 17 percent of its own energy for capitalization, exploration, development transportation and refining, with transportation capital, equipment and fuel costs accounting for approximately 2 to 4 percent (1). For the efficient transportation

of petroleum products with the degree of market flexibility which is required, waterborne transportation is essential. As illustrated in Table VII-1 the overall efficiency for all modes of transportation is very near 100 percent. The ancillary energy requirement data are not comparable for different modes of transportation, however, because each mode is assumed to transport the oil a different distance. The selection of one transportation mode over an alternative mode would depend on the distance travelled, products being transported, volumes, schedules, and availability of alternatives and existing transportation systems. Due to the transportation systems which have been developed, the efficiency for transporting large bulk shipments appears to decrease from: tanker, pipeline, barge, rail and truck. Although rail and truck have a high energy efficiency they lack the logistic ability to transport large bulk liquid shipments over great distances.

With the advent of the Alaskan crude shipments of approximately 308,000 tons per day being transported by tanker from Valdez to ports along the West. Gulf and East coasts, the annual domstic ton mile shipments of petroleum products will increase dramatically (e.g., one day's throughput will about equal the annual domestic shipment from Valdez of petroleum products in 1976). The efficient movement of crude oil from TAPS system is essential for significant energy conservation. To transport the crude from Prudhoe to a destination point 1,500 miles from Valdez the daily energy consumption will be approximately 29,500 barrels per day for the 800 mile pipeline segment and 16,000 barrels per day for the 1,500 mile sea leg.

C. POLLUTING SPILLS

Chapter IV discusses the various types of pollution which tankers and tank barges may possibly produce. Chapter V describes measures which may be taken to lessen the amounts and effects of pollution from these tank vessels. These include enforcement of various safety and environmental vessel design, construction and operational standards and other measures for controlling and cleaning up of ship generated pollution. While a reduction of air and water pollution is possible and achieveable, some pollution is inevitable. Operational discharges

Table VII–1
ENERGY EFFICIENCIES OF VARIOUS MODES OF TRANSPORTING CRUDE OIL

METHOD	ANCILLARY ENERGY (10^9 PER 10^{12} BTU's)	OVERALL EFFICIENCY (PERCENT)	DISTANCE FOR ANCILLARY ENERGY (MILES)
PIPELINE	3.69	99.3	300
TANKERS AND SUPERTANKERS	40.7	95.8	10,000
BARGES	25.7	97.4	1,500
TANK TRUCKS	14.1	U	500
TANK CARS	14.6	U	500

NOTES: Ancillary energy is input energy required to transport 10^{12} BTU's of energy. For example, tankers and supertankers require 40.7×10^9 BTU's for 10^{12} BTU's transported 10,000 miles.

U = Unknown

ADAPTED FROM: Energy Alternatives, a Comparative Analysis, University of Oklahoma, 1975.

for the most part can be controlled within limits; however, accidental discharges, especially those from casualties, result from the fallibility of man and equipment are more difficult to control. Various safety measures can reduce the probability of accidents and minimize the effects of them when they do occur, but environmental damage from significant accidental spills involving program vessels are a distinct possibility and can be mitigated only by employing practical and responsive clean up measures.

When polluting discharges from tank vessels and tank barges occur, they can have the following environmental effects. The marine environment is rich in both its variety and quantity of marine life. Oil and chemical pollution can effect, in varying degrees, all forms of marine plant and animal life from those that are the lowest in the food chain to those at the top. The degree of pollution, type of pollutant spilled, where the spill occurs, duration and the physical conditions under which it occurs determine the extent of the impact. After pollution has occurred, a normal balance may be regained in a short period of time or the impact may be more severe and recovery may require a span of many years. Little is known of what effect the chronic incremental discharge of ship generated pollutants may have on the marine food web. In addition to the effects upon plant and animal life, polluting discharges of the chronic type or major spills could affect beaches, water areas, and historic sites making them at least temporarily unusable for recreational purposes. If such pollution incidents occurred during periods of normal heavy visitor use, loss of recreational enjoyment and economic benefit to the vicinity could be substantial. Fishing, water sports, boating and many other marine related activities could be made much less attractive for an indeterminate period, depending upon the promptness and efficiency of the cleanup operation.

Certain chemical cargoes transported by this program do represent a hazard to crew and shoreline inhabitants, facilities and environmental communities. The release of these materials through polluting incidents is infrequent; however, the potential consequences are much more significant than those of the more frequent petroleum spills. With a release of highly flammable or toxic substances immediate risks

to human life are realized. To control against the occurrence of such events, certain operational procedures are developed for each class of materials to make the waterborne transport of these materials as safe as practical.

D. OTHER ADVERSE IMPACTS

The foregoing Sections detail the major environmental impacts which cannot be avoided. The Title XI Program will also involve some other impacts which are of lesser significance or which can be attributed only in part to this Program. Small amounts of air, water, noise, and solid waste pollution will result from construction, operation, repair, and scrapping of these vessels and barges. As pointed out in the individual sections, these forms of pollution can be and are likely to be kept within the limits of local, state, and national standards for these forms of pollution. To the limited extent that this program will contribute to the demand for the development of additional shipyard and port and waterway facilities, certain land use terrestrial, dredging, and filling will result in producing adverse environmental impacts.

CHAPTER VIII

RELATIONSHIP BETWEEN LOCAL SHORT TERM USE OF ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG TERM PRODUCTIVITY

A. EFFECT OF OIL AND CHEMICAL SPILLS

To the extent that the Maritime Administration Title XI Program for tankers engaged in domestic trade contributes to the increased use of vessels to carry oil and chemicals and consequently to spills, this present use may have an effect upon the present and future productivity of the U.S. Waterways. The extent to which the program will contribute to pollution of the U.S. Waterways is described in earlier chapters. Due to the current imperfect state of our understanding of the long term effects of oil and chemicals upon the environment and the scope of this program, it is difficult to quantitatively analyze the extensive relationships of the short term use of the waterways for oil and chemical transportation by program vessels in relation to the maintenance and enhancement of the long term productivity of these resources. The long term effect of incremental and major spillage of oil and chemicals cannot be projected until reliable data becomes available which will permit an analysis of the net result of the combined effects. The additional stress which the ecosystem can absorb is limited, but at present the bounds of these limitations are not known.

Although the toxic effects of chemical spills are of concern, the subtle effect of oil and chemical breakdown in the marine environment is also important and should be a major concern. Among the fractions from the petroleum breakdown are aromatic compounds; some of which (toluene and benezene) are very toxic. Other aromatic compounds, including those with carcinogenic properties, are dangerous if ingested. There is concern that these compounds might be concentrated and transferred through the marine food chain to man.[1] With increased controls by international groups, such as the Intergovernmental Maritime Consultative Organization (IMCO) and by domestic agencies such as the Environmental Protection Agency (EPA), the Coast Guard and Marad, the incidents of oil and chemical pollution should be reduced; however, adverse long term effects from

oil and chemical spills are still a possibility.

The net cumulative effects of this program will be to enhance the modernization of the U.S. tanker fleet. By the action of this program in concert with other federal pollution abatement programs the net spillage into U.S. waters would be expected to decrease due to better constructed and operated vessels and the decrease in dependence upon imported oil being brought into U.S. waters by foreign vessels.

B. NATURAL RESOURCES UTILIZED FOR VESSEL CONSTRUCTION AND OPERATION

The extraction and use of minerals and materials in the construction and operation of the Program vessels involves a short term use of our resources. However, because of the relatively small amounts of resources used in comparison with total national resources, and the ability to reclaim shipboard materials when scrapping vessels, the effect upon long term productivity should be quite small.

The fuel consumption for U.S. waterborne commerce has been estimated to be approximately 2.5 percent of the total U.S. transportation usage. This value is approximately one quarter of one percent of the country's net energy consumption. This utilization does represent a resource loss and does produce pollution emissions; however, this is required to maintain and promote the national productivity levels. As discussed, waterborne transport is one of the most efficient bulk freight moving systems, consequently, the promotion of this transport mode is in agreement with the national objectives of energy conservation and increased energy efficiency.

C. LAND USE FOR SHIPYARDS, PORTS AND WATERWAYS FACILITIES

To the extent that the construction and operation of program vessels may require shipyard expansion or the construction of new port facilities, and waterway shoreside and submerged lands will have to be dedicated for these purposes. The extent to which this program exerts pressure for such dedication and the types and amounts of lands which are expected to be so dedicated are difficult to quantitatively define. The

major long term effect is a reduction in the productivity of the submerged shoreland and wetlands affected due to dredging and spoiling operations. The adverse long term effects can be minimized by strict enforcement of environmental protection procedures being developed by the Corps of Engineers, U.S. Dept. of Interior Fish and Wildlife Service and other federal and state agencies which regulate such construction projects.

REFERENCE

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CHAPTER IX

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

A. EFFECTS OF OIL AND CHEMICAL SPILLS

The extent of potential of isolated oil and chemical spillage from program vessels has been previously discussed. Such spills may have irreversible and irretrievable environmental impacts.

The major significance of such spillage in the marine and aquatic environment is its potential effect on the biological resources. At this time, there is no evidence that low-level spillage has led to an irreversible commitment of resources, nor is there any conclusive evidence that it has not. More dramatic, though less probable, are the major cargo spills that could occur through the loss of one of the Program's vessels along the coastal zones and inland waterways. The extent and severity of such a spill's effects, including its irreversible and irretrievable injury to natural resources, would depend on the combination of location, amount, time of year, weather and sea condition. The chances of all these circumstances occuring to cause maximum damage and resulting irreversible consequences are in MarAds opinion, remote. It is not clear that spills of lesser impact would result in an irreversible commitment or damage to natural resources.

B. USE OF MINERALS IN VESSEL CONSTRUCTION AND OPERATION

The construction and operation of Program vessels will involve the use of mineral resources, some of which cannot be recovered. In the construction of vessels, coal, limestone, and other materials are used to produce steel and other materials used in construction. While many materials are recoverable, such as steel used in construction, other materials are not. The character of these materials is not unique, nor will the quantities used be such that their use is significant in terms of our national resources in the opinion of the MarAd staff.

The operation of the vessels will require the expenditure of energy resources. Although these resources will be irrevocably lost, the necessary work generated by their expenditure is a necessity to carry out waterborne commerce. As demonstrated earlier, vessels under this program include some of the most energy efficient transportation modes, thus the program is in agreement with the national goals of efficient energy utilization and conservation. Title XI Program vessels will be used in shipment of Alaskan crude to the lower 48, thus furthering the goals of Project Independence.

C. RESOURCE DEDICATION FOR SHIPYARDS, PORTS AND WATERWAYS

As discussed, the Title XI Program to promote domestic tanker commerce may inadvertantly cause a secondary development as a result of shipyard, port, and waterway expansions. If this should occur, the irreversible commitment of terrestrial, water, wetland, landuse, biological and geophysical resources will have to be made for these commitments. The specific commitments of these resources will have to be made on their own individual merits and the environmental impacts reviewed on a case by case basis. It is not the intent of this program to directly cause this development; however, it is recognized as a contributory factor.

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